HIGH TECHNOLOGY BUSINESS

PREVENTING AIR CRASHES

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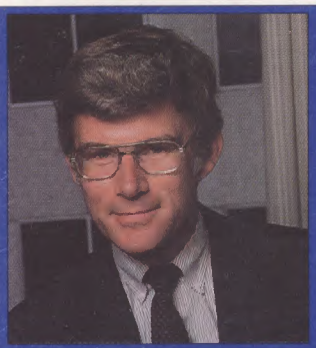
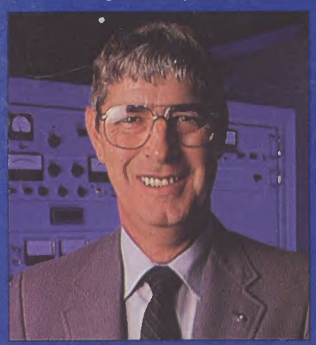


American Superconductor
Promotes High-Temperoture Wires
President George McKinney

Biomagnetic Technologies
Offers a New Medical Tool
President Stephan James

Eriez Magnetics
Puts Superconductors in Factories
President Chester Giermak

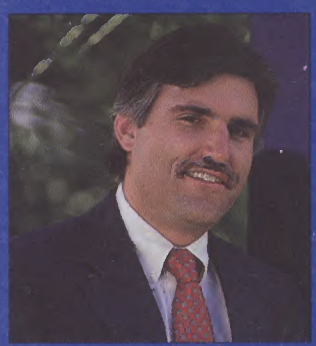
GA Technologies
A Leader in Magnets
Applied Superconetics President Ken Portain



Teledyne Wah Chang
Makes Better Niobium Supercanductars
Divisian President Al Riesen

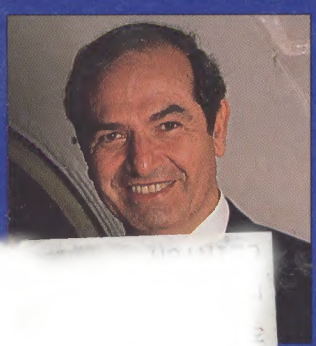
1988's HOTTEST SUPERCONDUCTOR COMPANIES

General Dynamics
Develops Electric Storage Systems
Energy Program Manager Robert Johnsan



Quantum Design
Researches Magnetic-Field Finder
President William Lindgren

GE's Medical Systems
Medicol-Imaging Pocesetter
Group Executive John Troni



Hypres
Superconductor Electronics Pianeer
President Sadeg Faris

A guide to the 48 contenders page 21

BEGINNING IN JANUARY, LEARN WHY INCOME MAY BE THE LEAST IMPORTANT PART OF A GOOD FINANCIAL PLAN.

On January 5, you'll meet a noted financial educator, Ken Rouse, on "Planning Your Financial Future," a 6-part series on FNN. Assisted by experts from Money, The New York Times, Forbes and similar organizations, Mr. Rouse will teach you a unique approach to financial planning, one that says the priorities and goals which shape your life – not a balance sheet – are the proper foundation for an effective financial plan.

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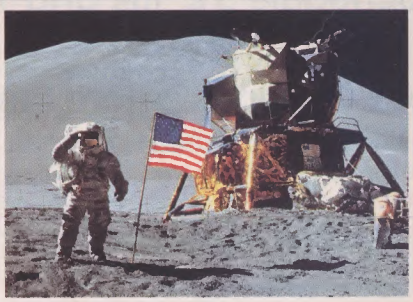

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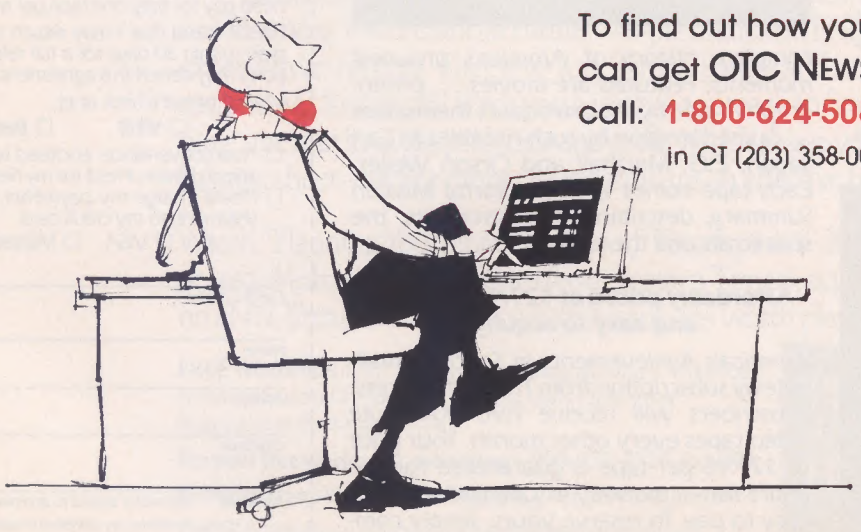

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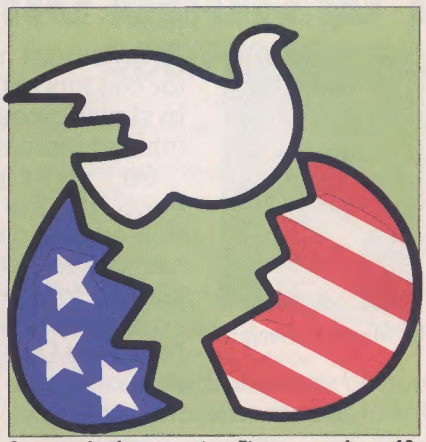
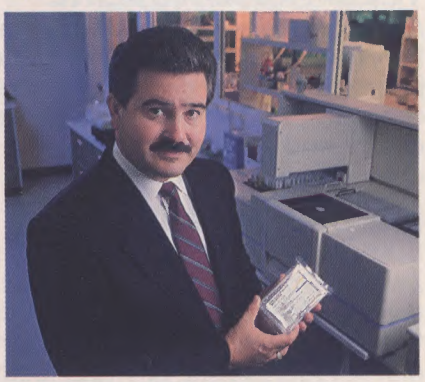


Superconducting: current profits, new promise, p. 18.



Better AIDS tests are on the way, p. 34.

Airlines try to collision-proof the skies, p. 28.

Cover photography, clockwise from top left: Joan Seidel, Rocky Thies, Eriz, Rocky Thies, General Dynamics, GE, A.J. Bernstein, A.J. Bernstein, Rocky Thies, Rich Iwasaki

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Published by
INFOTECHNOLOGY PUBLISHING CORPORATION

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Mark J. Estren

Taking Stock of Superconducting

AS WE CONTINUE to search for the most promising technologies and analyze their business ramifications, superconducting jumps to the top of any list.

Rather than just recap the technological advances in superconducting, which we reported in depth throughout 1987, we thought it was time to look at the hottest companies and the most promising areas of development as they stand at the beginning of 1988.

When we looked at established as well as new companies, we found that some of them are geared up to do very big business in superconducting, regardless of whether controversial recent discoveries can be turned into commercial products.

For example, Intermagnetics General, the company positioned to be the leading supplier of magnets for the government's proposed Superconducting Super Collider, has more than 300 people working on superconducting technology. Other companies, such as Bechtel and TRW, are looking for uses in other areas, such as Defense Department projects.

The research and the implications are global.

Major Japanese companies, including Matsushita, NEC, Hitachi, and Fujitsu, are heavily involved in moving the technology forward; several are particularly interested in how it can be applied to computers.

Meanwhile, Siemens of Germany is developing test magnets for medical markets. Plessey of England is developing ceramic superconductors, and Sweden's ASEA-Brown Boveri is researching high-temperature superconductors for use in generators.

New companies throughout the United States also are trying to cash in. They range from American Superconductor, which holds a license on a process for making ceramic wire and tape, to Conductus, a Palo Alto company developing new fabrication methods. Those two companies have raised more than $10 million in financing. Such numbers are a graphic indication of the financial community's interest.

Despite the excitement, the superconducting market was singed along with many other technology stocks in Wall Street's October debacle. To see how badly technology companies were hit, take a look at the High Technology Business Leading 100 on page 32.

The overall picture was not bright. In some cases, stocks that showed no price gain wound up leading their industries. However, others actually rose in value for the month.

The year is young, and some companies will undoubtedly find profit despite sobering economic conditions. We want to help you find them.

Charles L. Martin Jr.

Program Clarification

IN YOUR ARTICLE on Ada software ("Military Software's New Market," September, p. 43), our product, Model, was misrepresented by stating that it "churns out a nearly finished program." One of Model's strengths is that it generates 100 percent of a program, and one that is highly efficient.

Evan Lock
Vice President, General Manager
Computer Command & Control Co.
Philadelphia, Pennsylvania

The U.S. Needs Practice

PHILLIP A. GRIFFITHS' essay, "Research: A New Agenda," (August, p. 64) appears to neglect one basic phenomenon that may be responsible for the decline of U.S. competitiveness. In many decisive areas of technological endeavor, U.S. industry simply lacks the practical experience to compete with offerings from abroad.

Excellent research has been carried out by U.S. teams in many domains that could yield competitive and exportable products. For instance, jillions of dollars have been spent on supersonic passenger planes, advanced nuclear reactors, superfast trains and vessels, and hybrid communications networks. But almost none of these projects have been put into large-scale industrial practice in the United States.

Engineering and construction companies in other countries have been able to gather precious and indispensable experience through the practical operation of such technologies. No comparable know-how is accessible to U.S. companies in related fields.

The reason for this unfortunate phenomenon can undoubtedly be found on various levels. But as long as the myth of an absolute American technological leadership is maintained by politicians and the media as some sort of sacred cow—as long as it is only hinted from time to time that it may be lost instead of clearly emphasizing that it has already been lost in many important areas—no political or industrial action can be expected that would remedy the situation. It's time we sent that sacred cow to the slaughterhouse and had the courage to see the reality.

H. von Hardung, Ph.D.
Los Angeles, California

Also Worth Noting

I WOULD LIKE to thank you for the excellent coverage in your September issue (Also Worth Noting, p. 13) of our imaging software for the architectural and design market. You stated that the software was "tested and certified by the University of Miami," but the university did not offer any formal review process for our software, which was developed in conjunction with AT&T's Graphics Software Laboratory. The university did act as a beta site for our product. We are extremely grateful to the university for providing their services and hope to continue working with its Image Transformation Laboratory.

Cecil M. Thornhill
Mathematica Inc.
Lakeland, Florida

They Like It

BRAVO FOR your article on communications satellites,"Big Hopes for Small Dishes" (November, p. 41). I greatly enjoyed reading your concise, accurate reporting of the highly complex VSAT/corporate video market. Your insightful analysis of trends in competitive technology, strategic alliances, and customer applications was of significant interest. In this bearish financial market, we're still bullish on tech business.

Susan Kalla
Contel/American Satellite Co.
Rockville, Maryland

I REALLY LIKE the magazine's new look, and look forward to following the latest developments in high technology through your coverage.

Bill Bryant
Director of Communications
Inforum
Atlanta, Georgia

We welcome comments from our readers. Address letters to Editor, HIGH TECHNOLOGY BUSINESS, 214 Lewis Wharf, Boston, MA 02110. We reserve the right to edit letters for length and clarity.

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— Senator Philbert "Filibuster" Peabody

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New Developments

Issues, products and advances that help create new opportunities for high-tech businesses

A Computer Behind the Wheel

FORKLIFT leader Caterpillar Industrial is betting that its new line of self-guided vehicles can lead the company through a market littered with the hulks of previous attempts.

Caterpillar bases its leap into high-tech materials handling on a driverless carrier that navigates around a factory to help with such tasks as moving heavy parts to production machines.

Self-guided vehicles are the latest wrinkle in automatic guided vehicles that follow invisible pathways. Caterpillar's models don't even need a path; they store a detailed map of a building in their computer memory. Sensors keep track of the machine's movements, and a laser scanner atop the vehicle searches for bar-code location labels posted throughout the building. Using triangulation, the carrier needs to find only two labels to pinpoint its location. A typical two-vehicle setup might lease for about $6,000 a month.

Cat's system offers more flexibility than fixed-path vehicles, but it may still have problems getting started in a troubled market. Industry leader Volvo Automated Systems of Sterling Heights, Mich., is rumored to be up for sale by its parent, the Swedish automaker. Also, Flexible Manufacturing Systems of Los Gatos, Calif., which makes self-guided carts for clean rooms and light manufacturing, is still reeling from a shakeout of its entire sales force.

Still, Caterpillar Industrial, a Mentor, Ohio, subsidiary of the heavy-equipment maker, expects overall sales of automatic guided vehicles to reach $1 billion annually within five years. "If self-guided vehicles replace forklift trucks, the potential is much bigger," says Dave Butler, merchandising manager for the vehicles. Not surprisingly, Caterpillar plans to add a self-guided forklift to its flat-topped and towing carts.

A new vehicle from Caterpillar finds its own way around the factory.

DAVID WILDER

Discovery Creates Hot Fashions

A TREATMENT that enables fabric to store and release heat could change the way Americans keep warm.

The new process, patented by the federal government, treats various weaves of cotton, wool, and synthetic fibers with an inexpensive polymer called polyethelyne glycol. When the mercury rises, the polymer's molecules absorb a large chunk of heat and undergo what is called a phase change, which is similar to what happens when ice turns to water. The phase change locks the stored heat in the fabric until the surrounding temperature drops below the particular polymer's phase-change temperature. At that point, the molecules begin to rearrange themselves, releasing the stored thermal energy.

Once charged with heat by a complete phase change, a thin jacket of treated material would release enough

warmth to match the cold-protection capabilities of bulkier garments. Similarly, a phase-change blanket could soak up household heat all day and warm sleepers all night without electricity. 3M is working with the Air Force to make heat-storing gloves for pilots.

Treated garments would stay locked in at the phase-change temperature even as the air temperature fluctuates, adapting as the wearer moves inside or outside. The polyethylene glycol bonds to the textile fibers and will not wash out.

Richard Parry of the Agricultural Research Service, who heads the federal government's commercialization push, is seeking industrial partners to develop treated fabrics. As with a recent licensing deal for a new heat-conducting alloy (see New Developments, December 1987), the commercialization drive takes advantage of recent changes in federal patent policy to offer exclusive licenses.

UNIVERSITY OF VIRGINIA REHABILITATION ENGINEERING CENTER

Advanced wheelchairs make life easier for 1.5 million people.

Thoroughly Modern Wheelchairs

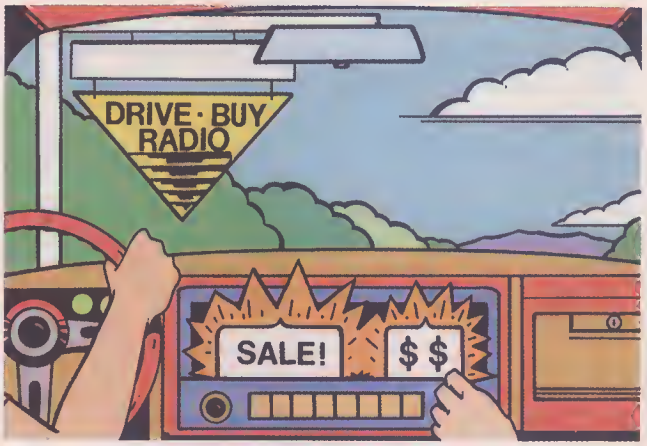
SLEEKER, MORE mobile wheelchairs promise to help the United States' 1.5 million wheelchair users remain independent.

In addition to such basic improvements as adjustable backs and better wheels, many wheelchair manufacturers now use aircraft materials to build lighter, stronger frames. The new models also feature spoked wheels to cut overall weight almost in half—to less than 30 pounds. A new chair for athletes, made by Topp End of St. Petersburg, Fla., weighs only 13 pounds.

Lighter chairs from companies such as Motion Design of Fresno, Calif., offer greater maneuverability, but that's only the beginning. Market leader Everest & Jennings in Camarillo, Calif., has created body-tailored, rigid-frame chairs customized for each user. The University of Virginia's Rehabilitation Center is developing a computer-aided design system to create customized seating, and has made a chair that lets owners row levers like oars instead of pushing wheels.

Fortress Scientific of Downsview, Ontario, offers motorized chairs with microprocessor-controlled, closed-loop control systems to maintain a constant speed and turn rate. So does Invacare, based in Elyria, Ohio, which also plans to build a chair that employs a sip-and-puff tube to let users answer the phone, turn on lights, and work at computers.

The manual wheelchairs cost $300 to $2,000; powered models run $5,000 to $6,000. In addition to improving performance, the industry is also paying new attention to cosmetics, offering color-coordinated designs and racing stripes.



BRAD HAMANN

Radio Days... and Nights

FOR ABOUT $300, Drive-Buy Radio will let any business with access to a parking lot or heavily traveled road capture a "virtually untapped market: the drive-by," says Steven Rand, president of INR Technologies. The Northridge, Calif., company makes the product—an FCC-approved FM transmitter combined with an endless-loop cassette player. Using a special antenna, the system broadcasts its message farther than 300 feet. To encourage people to tune in, businesses post a sign in a prominent location near the transmitter. Interested motorists set their dial to the unused FM frequency noted on the sign to hear the commercial.

Interest so far has come from the real-estate industry, but, according to Rand, Drive-Buy Radio can be used by many other businesses, particularly retail and restaurant outlets. Rand expects sales to top 30,000 units this year.

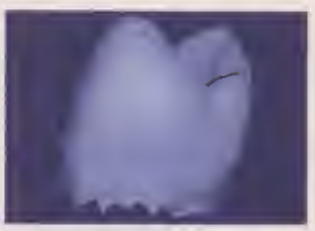
Dental Crowns While You Wait

COMPUTER-AIDED design may soon provide patients and dentists with a fast and inexpensive new way to replace teeth. Researchers at the University of Minnesota are developing an automated technique for making dental crowns.

The system digitizes photographs of the tooth in question to create a three-dimensional model of the crown on a computer screen. Software developed at MIT then tells a milling machine how to make the crown.

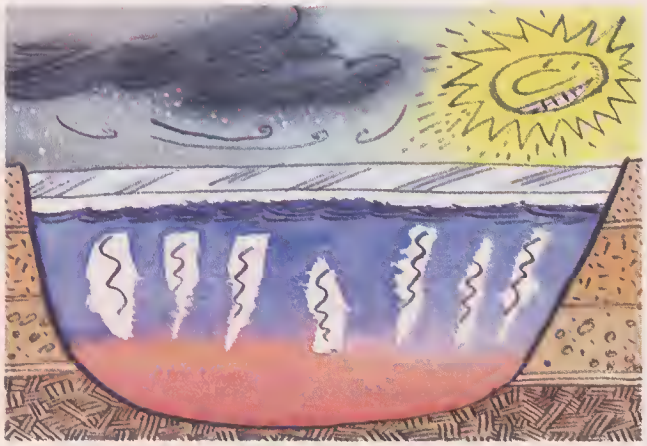
The process saves money by substituting stainless steel and precast ceramics for costly gold and unformed ceramics. The one-hour process also eliminates the need for expensive temporary crowns.

The complete system will be available this year for $150,000 to $200,000. Small dental practices can buy the image-collecting equipment for $5,000 and contract with a central laboratory to make the crowns.



UNIVERSITY OF MINNESOTA

Computers ease dental visits.



HAL MAYFORTH

Solar Ponds Go North

CAN A frozen pond produce heat?

The prevailing wisdom held that it just wasn't possible, and companies planning to use solar ponds to satisfy their heating needs were forced to stick to southern climes. But NKK, a Japanese steelmaker, reports that it has successfully demonstrated the efficiency of solar ponds even in places where the temperature falls below freezing during the winter.

Solar ponds collect heat from sunlight and store it as hot salty water at the bottom of the pond; water at the surface acts as an insulator. The pond operator then taps the hot water and uses it for space heating or for conversion to electric power.

NKK's 1,500-square-meter solar pond on Japan's Hokkaido Island, the northernmost ever built, can supply water at 160 degrees Fahrenheit throughout the day in the summer and at 86 degrees or higher even when the pond is covered with ice.

The nine-foot-deep pond has a light-use factor of about 10 percent, versus the 15 to 20 percent recorded by solar ponds located at more advantageous sites abroad, according to a company spokesman. So far, more than a dozen countries have experimented with solar ponds, and a commercial plant built by Ormat Systems in Israel can generate 5,000 kilowatts of electricity.

Although NKK's experience may expand the geographic range for solar ponds, operation of an economical solar pond requires inexpensive flatland, ample sunlight, a supply of cooling water, a low-cost source of salt or brine, and access to utility connections.

Process Builds Tougher Plastics

RESEARCHERS at the Rensselaer Polytechnic Institute in Troy, N.Y., have come up with a technology that may help create products with the heat- and impact-resistance demanded by advanced aerospace applications.

Many theoretically possible combinations of polymers—the raw materials for plastic—turn out to be unstable in the finished product. But a process patented by Rensselaer's Bruce Nauman increases the stability of any theoretically sound combination of polymers.

The process, called "compositional quenching," has led not only to the development of new plastics, but also offers more control over a plastic's gloss, resistance, and strength.

The new method calls for plastics manufacturers to dissolve two or more polymers in a common solvent, then heat the mixture under high pressure to about 500 degrees Fahrenheit. Once the polymer particles have dispersed evenly throughout the mixture, the pressure is suddenly released, vaporizing the solvent while suspending the dispersion of particles.

Better control of particle size is the key to the technique. Particle size controls a plastic's characteristics, and "particle size simply cannot be controlled in previous methods as it can be with compositional quenching," says Nauman.

High Technology Systems, a manufacturing and marketing company in Troy, has licensed the technology from Rensselaer to enhance a NASA technique used to make laminating resins for aircraft parts, adhesives, and printed-circuit boards. General Electric helped fund the research and plans to use the process on its laminating resin, called Noryl, which is used to make pumps, computers, cars, and electronic products.

Smaller, Faster Medical Tests

A NEW TESTING technology may offer doctors, and eventually consumers, an alternative to standard diagnostic tests. Called capillary-tube tests, the disposable plastic devices hold the reaction in tiny ⅛-inch-diameter tubes, creating a more sensitive test that may be able to detect diseases at an earlier stage.

Allelix Inc.'s Diagnostics Division in Mississauga, Ontario, developed the technology and is working with drug companies such as Richardson-Vicks to develop specific tests. Allelix plans to release tests for strep throat and pregnancy this year and is planning to add tests for sexually transmitted diseases and heart disease soon.

ALLELIX INC., DIAGNOSTICS DIV.

Color-coded capillary-tube tests.

According to Allelix, the capillary test's one-step method reduces user errors. Doctors or consumers mix a sample such as a throat scraping with ingredients contained in three cylinders inside the 1×3×1-inch plastic device. Pushing the cylinder tops starts a chemical reaction, and within several minutes the liquid in the tube changes color to indicate the results.

Patented in the United States, the self-contained device makes disposal safe and easy, giving the product a leg up on the messier tests with which it competes, according to Allelix senior research scientist Scott Winston. The company expects the world market for rapid diagnostic tests to grow 18 percent annually to $1.8 billion by 1992.

The Fat Of the Matter

FUTREX INC.

Better than a scale, the Body Fat Analyzer offers more help to dieters.

MOST OF the nation's 40 million dieters don't really know if their diets are working. That's because their problem isn't really excess weight, but excess body fat.

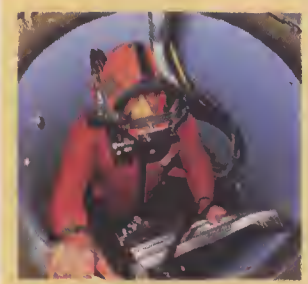
A bathroom scale can't even address the problem, and traditional methods of measuring body fat depend on unreliable calipers, accurate but complex and costly water-buoyancy or electrical-impedance tests, or uncomfortable blood tests.

A new product, the Fitness & Body Fat Analyzer from Futrex, may help dieters get better results. Using technology developed 10 years ago by the U.S. Department of Agriculture to measure substances such as fat, protein, starch, and sugar in agricultural products, the Futrex analyzer works on the principle that fat absorbs certain frequencies of infrared light in measurable ways. To use the device, people touch the infrared light wand to their bicep. The analyzer reads the amount of light reflected and calculates the arm's fat content, which Futrex says accurately reflects the percentage of total body fat.

The product includes a 256-kilobyte microprocessor that compares data such as age, weight, height, and gender with National Institutes of Health standards and prints out an individualized health profile that includes a diet and exercise regimen.

Bob Rosenthal, who had used the technology for agricultural applications, established Futrex to go after the health market. Based in Gaithersburg, Md., the start-up company has begun shipping the $1,490 analyzer to schools, hospitals, athletic teams, doctors' offices, and health clubs across the country. Futrex also hopes to sell the device to the armed forces. A $290 home model, which does not produce printouts, is due this spring. Futrex hopes to sell 100,000 of the units, which are manufactured in Japan by Keet Electric Laboratories.

ALSO WORTH NOTING



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French divers test new air mix.

■ Experiments that let divers operate as much as 1,700 feet under water by breathing a mix of hydrogen, helium, and oxygen could have dramatic implications for offshore oil drillers. France's Comex, which sponsored the experiment, says that adding hydrogen to a diver's air supply increases comfort and allows higher efficiency at or below conventional working depths of 650 to 1,000 feet. The new mixture could let divers work at the 1,300-foot depths required by the Norwegian Troll oilfields. Other possible uses include oceanographic research, salvage operations, and archeological expeditions. Though the gas has not yet been used in a commercial operation, Comex and French Navy divers tested the mixture in dives this summer. More tests are planned over the next two years.

■ Aerojet TechSystems Co. of Sacramento, Calif., has completed flightweight testing of the first pump-fed liquid-fuel space engine designed to position large payloads in orbit where they remain above the same spot on earth. According to Aerojet, which is owned by GenCorp, liquid-fuel top stages are more reliable than solid-fuel boosters. Liquid-fuel rockets can be tested on the ground and then refueled before launch, unlike solid-fuel rockets. Aerojet's Transtar engine uses a turbopump to manage fuel flow, resulting in more power from a lighter engine. The combination of high performance and light weight is designed to let the new engine move heavier payloads than conventional engines, the company says. Typical payloads might include communications and defense satellites.

■ More gasoline per barrel of oil, purer drug compounds, and new chemicals may result from a molecular sieve being developed by Dow Chemical Co., working with Virginia Polytechnic Institute in Roanoke, Va. The sieve, called VPI-5, is a fine white powder structured like a honeycomb that separates molecules and acts as a catalyst for chemical reactions. Its pores are 75 percent larger than the sieves oil companies have been using since the 1960s, allowing refiners to capture a wider range of molecules used to make gasoline. Virginia Tech developer Mark Davis claims that VPI-5 will improve gasoline yield and make it easier to derive and purify certain drugs. The sieve must still be tested under industrial conditions.

■ Nippon Telephone & Telegraph (NTT), the Japanese phone company, has followed the success of its Duet public telephones with the Plus One, a two-receiver phone for home use. The Duet, which has two receivers in a slightly enlarged phone booth, is popular with Japanese youths who cram into the booths in groups to call their friends. NTT has installed 450 Duets in areas popular with teenagers, and hopes the Plus One will tap the teen market in the home and offer an alternative to speaker phones. NTT sells the new phones through a subsidiary for about $95. NTT is forbidden to export, but would consider licensing the idea to interested manufacturers.

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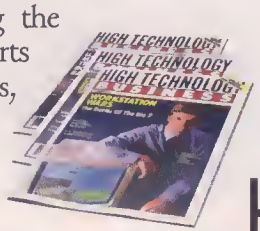

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Picking The New Standard

INTEL FUELS DESKTOP SYSTEMS' NEXT GENERATION

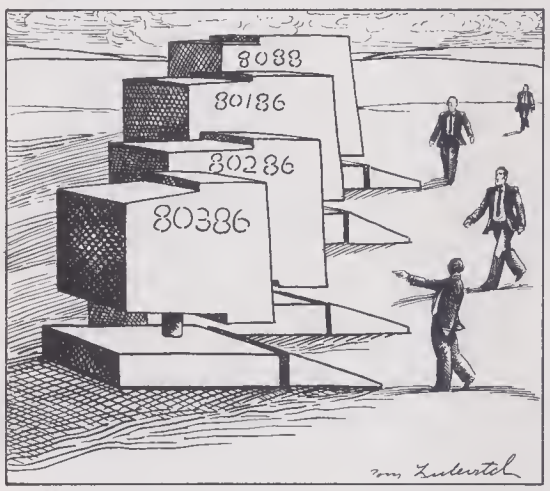
■ **By Andrew M. Seybold**

INDIVIDUALS contemplating the purchase of desktop computer systems must try to find sensible answers to some not-so-simple questions: Which generation of desktop computer is the most cost-effective choice for my business today? And which system will continue to meet my needs in the future?

In the past six years, Intel Corp. has provided microcomputer makers with four generations of its 8086/8088 chip family: the 8086/8088, 80186, 80286, and 80386.

The 8088 found favor first with IBM when, in 1981, Big Blue chose it for the then-new IBM PC. In achieving this starring role, the 8088 established itself as a sort of "desktop standard."

The next member of the family, the 80186, fared less well. This transitional chip was used in products from only a handful of companies before being supplanted by the 80286. As the engine that powered IBM's second-generation desktop computer, the PC-AT (and a slew of clones), the 80286 soon became the next "desktop standard."



TOM LULEVITCH

But a new standard is emerging. In September 1986, Compaq Computer Corp. introduced the Compaq Deskpro 386, the first desktop machine from a major company to use Intel's 80386 chip. In the eyes of Compaq president and CEO Rod Canion, the 80386 is the chip that will ignite the industry and provide the best platform for the next generation of desktop computers.

Unlike its less powerful predecessors, the 80386 does not place artificial constraints on software developers. The chip also provides hard-level support for multitasking. Consequently, desktop computers built around the 80386 will be able to do something that heretofore has been the exclusive province of minicomputers: They'll be able to run several programs at once. In addition, programs developed for 80386-based computers will be larger, more powerful, and much more sophisticated than those developed for earlier-generation machines.

Since the Deskpro 386's introduction, various other companies have introduced 80386-based machines, including IBM, ITT (now Xtra Computer Systems), Wang, Tandy, AST Research, and Epson. Although most of the computers sold in the last quarter of 1987 were based on the 80286 and 8088, the 80386-based machines are making amazing headway, despite their higher price tags.

Why is everyone in sight suddenly rushing into the 80386 market? According to Safi Qureshey, one of the founders of AST Research (a leading supplier of both desktop computers and add-in hardware), "The 80386 chip is the one we have been waiting for. It is the chip with enough power and flexibility to move the power of the minicomputer down to the desktop. This chip, and the flexibility it affords, will be responsible for the next generation of software—software that is smart and powerful enough to be able to assist the user in all kinds of different ways."

Adrian King, Microsoft's OS/2 product manager, suggests that visible evidence of such a trend can be found in the emergence of powerful new software in the areas of desktop publishing and computer-aided design. Here and elsewhere, applications that once required large computer systems selling for hundreds of thousands of dollars are now able to operate on 80386-based systems which, including software, can often be purchased for less than $10,000.

Most software and hardware development companies are committed to, and will continue to support, the other Intel processors (the 8086 and 80286), but the consensus seems to be that the 80386 offers a more stable and versatile platform for the desktop computers of the future.

Microsoft chairman and CEO Bill Gates has said that either the 80286 or 386 platforms could be right for a particular business. However, note that Microsoft itself will be purchasing 80386 systems as its computer system requirements increase.

All of this strongly suggests that the 80386 will soon emerge as the new "desktop standard," and that beyond the transition period of the next few years, most innovations and enhancements will be made for the 80386 world.

This does not mean that existing machines will not continue to be useful during the next decade. They most certainly will. But for computer users who want to take full advantage of the next series of major desktop-computing advances, there's little doubt within the industry that 80386-based systems will become *the* Intel-powered personal computers of choice. ■

Andrew M. Seybold is editor-in-chief of Andrew Seybold's Outlook on Professional Computing, *a California-based newsletter.*

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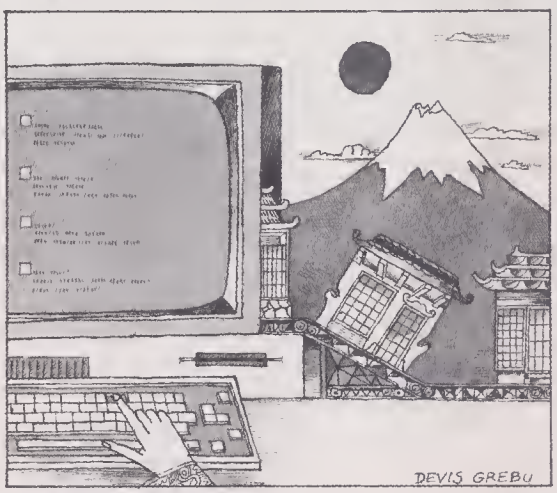
Prefab Houses Move Upscale

NEW TECHNOLOGY ERADICATES A LOW-END IMAGE

By Robert Chapman Wood

IN JAPAN, companies build houses the same way they build cars and computers. High-technology materials and techniques help prefabricated houses live up to the Japanese reputation for quality, and thus appeal to upscale buyers.

American housing manufacturers make highly standardized, low-cost products for the low end of the market. In contrast, Japan's five leading prefab-house makers—Sekisui House, Daiwa House, National House, Misawa Homes, and Sekisui Chemical (which owns about 20 percent of Sekisui House, but also produces homes using its own manufacturing system)—have each developed a computer-aided design and manufacturing system to tailor new houses to a purchaser's needs.



DEVIS GREBU

The rise of Japan's manufactured-housing industry, which accounts for 15 percent of all Japanese housing construction, was no accident. In the 1950s and 1960s, the country launched a deliberate effort to create housing manufacturers organized along the lines of America's major automobile manufacturers, complete with plenty of capital. James McKellar, director of MIT's Center for Real Estate Development, says Japanese housing makers typically spend 1.5 percent of their income on research to create features and high-quality materials unavailable in prefabricated houses made in the United States.

Surprisingly, Japanese techniques do not significantly affect prices. McKellar says savings from mass production represent only a small share of the price of a house. In most cases, land, regulatory approvals, site preparation, design, materials, and similar factors account for far more of a house's final cost than does on-site labor.

Instead, the Japanese advantage rests on special features and advanced materials. For example, most of Japan's major prefabricated-housing companies offer hot-water heating systems that eschew unsightly, hard-to-maintain baseboard radiators in favor of floor panels that contain tiny hot-water pipes. The companies also pre-cast entire bathrooms out of tough, water-proof, easy-to-clean plastic. The Sekisui Group and National Home are among the leaders with these systems.

Both Sekisui Home and National Home build one-piece walls of aluminum and foam—inexpensive materials that provide good insulation. Misawa Home makes ceramic wall panels to replace concrete. Although the panels use the same raw materials as concrete, the Japanese carefully control baking and air injection to create a lighter, better-insulating, and at least potentially cheaper wall material.

The Japanese have also created systems to ensure excellent ventilation without heat loss. Kobori Construction, a smaller firm, has developed two-story panels made of an egg-carton-like plastic to efficiently insulate the home while allowing moisture to escape into air channels that vent through the roof.

Perhaps most importantly, Japanese prefabricated-housing makers have adapted quality-control techniques originally developed for the automotive and appliance industries. "The great dilemma we face in the housing industry," says McKellar, a former home builder in Canada, "is that your work is only as good as the particular laborer you hire. You can't impose a system of quality control when you're constructing everything on-site and the construction has to be adapted to the weather and the mood of the craftsman."

The Japanese ensure predictability by doing most of their work in carefully controlled factories. For example, the lifespan of a typical roof built on-site in the United States can vary considerably, averaging perhaps 20 to 30 years. According to McKellar, Japanese manufacturers confidently predict that their roofs, which include a tough, sealed plastic membrane and are built entirely at the factory, will last as long as 50 years.

But exporting houses is not easy, and dramatic adaptations would be required to meet U.S. needs. Instead, several of the major Japanese manufacturers, notably Misawa, are looking to license their techniques abroad.

McKellar sees possibilities for Japanese techniques in the United States, but worries about the cyclical nature of the U.S. homebuilding industry. Traditionally, the extreme volatility of that market has led U.S. builders to conserve capital by sticking to low-technology construction. Without the kind of long-term financial support provided by the Japanese government, the American dream may not include high-quality manufactured housing. ■

Robert Chapman Wood is a writer and business consultant who has specialized in the Orient for more than 12 years.

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Competitors Team Up

JOINT EFFORTS REDUCE PROJECT RISKS

■ **By Charles W. McCoy Jr.**

THE UNITED STATES has always been known for keen competition among its businesses. However, bidding on many specialized high-technology contracts is becoming so complex and risky that companies are abandoning the traditional elbowing and shoving in favor of cooperation and joint ventures. Many large competitors now pool their resources to form special project partnerships or teaming agreements, often with government encouragement.

For example, Baxter Travenol Laboratories Inc. recently joined with AT&T and IBM to bid on a Department of Defense hospital-automation contract. This $1.1-billion project to install a state-of-the-art computer-information system for 700 military health-care facilities throughout the world could eventually result in $3 billion worth of government business. Baxter brings its expertise as a health-care provider to the team; AT&T handles the telecommunications and IBM contributes the computer hardware.

MARK KSENIAK

Other companies that have learned the benefits of teaming arrangements include Westinghouse Electric, which has joined Texas Instruments in work on the Advanced Tactical Fighter radar program for the U.S. Air Force, and Comsat Laboratories, which is linked with Computer Sciences in its bid on a global-communications network for the State Department.

Finding the appropriate teaming partner may not be as easy as it looks. As in any marriage, the partners may turn out to be incompatible. Anyone examining the feasibility of such an arrangement must assess the partners' ability to work together, as well as their technical and fiscal capabilities. Such an examination is important to investors as well, who should look at which companies have been able to assemble the strongest team for a particular contract.

Especially important to any teaming arrangement that involves high technology is the way team members agree to share each other's trade secrets, technologies, expertise, patents, copyrights, and licenses. In a typical teaming arrangement, competitive technical organizations work in an atmosphere of cooperation. In the process, each educates the other with information that otherwise would not have been exchanged.

However, once that information is shared in the minds of engineers from a competing organization, it is very difficult to protect the trade secrets of one company from both unconscious and conscious use by the other company when the engineers return to their separate organizations. This fact and its potential impact on each company's future are important elements to consider in any assessment of a team project and, indeed, in any decision on whether to enter a team arrangement at all.

The U.S. Department of Justice has recognized that teaming arrangements can provide economies of scale, aid in capital formation, prevent duplicate research and development efforts, and spread legal liability. Most importantly, such arrangements allow a team to undertake what each company could not accomplish on its own.

The antitrust laws do not, however, permit teaming arrangements that limit competition beyond the specific projects for which the team is formed. Generally, teaming arrangements for a single project will pass antitrust scrutiny if they do not eliminate future competition in other areas. Although companies that provide specialized work under government contracts have argued that they should be exempt from antitrust laws, these arguments have generally not been successful.

In determining whether a particular teaming arrangement passes antitrust muster, the government considers a variety of factors. Among them is the question of whether the arrangement is narrowly tailored. In general, enough other competitors must remain after the teaming to allow those competitors to form their own teams to compete for the project. Moreover, the government may scrutinize a teaming arrangement to determine whether one of the partner companies has the ability to compete without teaming. If so, the government may argue that the adverse impact of eliminating competition outweighs any benefits the teaming arrangement may create.

Because of the risk and technical complexity of many high-technology projects, the number and breadth of teaming arrangements will continue to increase. Companies who were once bitter competitors will find themselves partners. Those who cooperate best will have the greatest chance of success. ■

Charles W. McCoy Jr. practices law with the Los Angeles firm of Sheppard, Mullin, Richter, and Hampton.

1988's Hottest Superconductor Companies

Media hype aside, superconducting is serious business for a growing number of companies

By T. A. Heppenheimer

NO ONE CAN deny that superconductors were 1987's technology superstars. Dramatic laboratory breakthroughs thrust them into such prominent places as the covers of leading national magazines. But so much emphasis on breakthroughs in advanced research and the promise of a technological revolution obscures the fact that superconductors already support a growing industry.

But there is still room for expansion. Industry revenues were just $300 million in 1987, according to Strategic Analysis, a business and market-planning company. Strategic Analysis expects the 1988 superconductor market to remain at about the same level, and projects an increase to $3 billion by 2005, barring an unforeseen breakthrough in technology. That's an average growth rate of only about 10 percent, quite modest for a high-tech business.

Still, even the current market for superconductors represents sizeable potential for the 48 competitors involved worldwide. The entire commercial market is for the older niobium superconductors, largely used for making ultra-high-powered electromagnets, although electronic applications are growing. A promising potential market for niobium magnets is the proposed Superconducting Super Collider, a $4.4-billion Department of Energy project for conducting basic, large-scale physics research.

The markets for niobium superconductor products are dominated by established companies, especially General Electric and GA Technologies, leaders in producing magnetic-resonance imaging equipment used in medical diagnosis. Other companies are finding they can prosper by specializing in other areas. Hypres, for example, is carving out a dominant role in the nascent market for superconducting electronics. Biomagnetic Technologies has developed a promising new imager that can detect brain activity, and Quantum Design is marketing a superconducting device that monitors metal corrosion.

Meanwhile, there's been a recent spate of startups that hope to cash in by developing usable, high-temperature superconductors. However, this latest generation of superconductors uses ceramic materials, which are brittle and much harder to work with than metal. Most research is looking for ways to produce workable versions of these ceramics. However, experts—such as IBM senior researcher Paul M. Grant and Stanford University physicist Theodore H. Geballe—point out that the ceramics cannot yet carry enough current for practical use. Therefore, ceramic superconductors cannot significantly displace the niobium-based products now in use,

FOLKY THIES

Biomagnetic Technologies' Steven James opens a new field for established, niobium superconductors.

they contend. Hence the prospects for ceramic superconductors remain wildly speculative.

Nevertheless, money is being spent on ceramic research, and many entrepreneurs dismiss the above attitude as needlessly pessimistic. Venture capitalists have committed about $25 million to start ceramic-superconductor companies, and have poured an equal amount into niobium-superconductor companies. Other financing for superconductivity research comes from federal support, which totalled $29 million in 1987. The National Academy of Sciences recommends a boost to $100 million this year. In addition, companies such as IBM and AT&T Bell Labs are doing significant research.

Superconductivity work falls into 10 categories. In the niobium segment, five of the activities cater to commercial markets. These markets involve small custom magnets for research; large custom magnets for electric power and energy research; production magnets, especially for magnetic-resonance imaging; electronic products; and wires, rods, and cable, usually used to make magnets.

Another niobium activity is research and development to come up with products that offer improved superconductive properties.

All ceramic superconductor activities focus on research. Studies are underway on the principles and properties of superconductivity, the production of ceramic wires and tapes, the application of superconducting coatings, and future superconducting uses. With ceramic superconductor activity still centered in research, the technological revolution is probably a lot farther away than last year's media hype would lead you to believe; the new superconductors being developed in laboratories face formidable technical barriers.

Superconductors are materials that give no resistance to

electric currents. As a result, all the power that goes in one end of a superconductor comes out the other. They produce particularly strong magnetic fields, and they bring new physical principles to electronics, yielding ultra-fast circuits and very sensitive instruments.

The problem is that today's superconductors, which are made from alloys of the metal niobium, only work when they're cooled to sub-Arctic temperatures using liquid helium. That requires expensive cooling equipment and makes the technology too costly for all but special uses, such as magnetic-resonance imaging machines, and a few electronic devices for defense and industry.

Niobium production magnets

1987 SIZE: $200 million

PLAYERS: GA Technalagies, General Electric, Hitachi, Intermagnetics General, Oxford Instruments, Siemens, Tashiba

Researchers are creating superconductors that work at somewhat higher temperatures, although they still must be cooled with liquid nitrogen. Because they'll be cheaper to use, these new superconductors are raising hopes that they'll bring advances such as computers that operate with unheard-of efficiency, magnetically levitated trains, and cross-country electric power lines.

This adds up to an emerging, technology-driven industry that will no doubt be subject to surprising developments. But for the near term, the business of superconductivity will focus on the following 10 areas.

Niobium production magnets. Production superconducting magnets, built by the hundreds to standard designs, represent the backbone of the industry. Last year's sales reached about $200 million. About $150 million of that was spent on magnetic-resonance imaging, a technique that uses magnetic fields and radio waves instead of X rays to look inside the body. More than 300 such systems are sold annually, a solid commercial base. Carl Rosner, president of Intermagnetics General, expects medical magnet sales to rise to $350 million by 1990.

The lion's share of this growth should go to Siemens and General Electric, current market leaders for magnetic-resonance-imaging machines. About half the niobium magnets used in these machines come from Oxford Instruments. Other major suppliers are GA Technologies and Intermagnetics General.

These companies could also get a boost in the next two years from the Super Collider, which would require about 10,000 magnets that could yield an additional $300 million in revenues each year. However, the potential Super Collider market rests on the capricious will of Congress. So far the program has generated a lot of attention, largely because the facility is expected to bring a considerable boost to the regional economy in its location. But when the Department of Energy picks a site in July, lawmakers from the 49 other states will probably lose interest in the program, and the project could be ripe for a major cutback early in the next administration.

Niobium electronics. In electronics, where the market for superconductors stood at about $40 million last year, attention focuses on the Josephson junction. Named for Nobel-winning British physicist Brian Josephson, the junction is a speedy electronic switch—the fundamental unit of a computer—that operates a thousand times faster than a transistor and uses a thousand times less energy. From 1969 to 1983, IBM invested $300 million to develop a superconducting computer, but then abandoned the effort in favor of continued development of silicon. Now Hypres owns IBM's Josephson licenses and is pursuing other uses. The first company to offer a product based on Josephson circuitry, Hypres sells an oscilloscope that does laboratory testing and is five times faster and 50 times more sensitive than comparable devices.

Such innovation puts Hypres above other market-segment contenders—the company has garnered about half the $25 million in venture capital spent on niobium technology. But two new challengers, Biomagnetic Technologies and Quantum Design, have suddenly entered the running with innovative new applications for superconducting in electronics.

Biomagnetic Technologies has developed a novel method of medical imaging to detect the weak and evanescent magnetic fields produced by the brain's neurons. This method pinpoints brain cells that cause epilepsy and promises early diagnosis of such diseases as Alzheimer's and Parkinson's, according to the company. The Food & Drug Administration recently approved the instrument, called the Neuromagnetometer, for use in research hospitals; that has prompted Biomagnetics to abandon all other work and focus on neuromagnetism. The Neuromagnetometer costs $825,000 to $1.3 million.

Quantum is marketing the Magnetic Property Measurement System to universities and research labs, many of which use it in advanced superconductivity research. The product is already a runaway success; the company has about a 16-month order backlog. But perhaps more promising is a rust detector based on the system, being developed for a research program with MIT. The device senses the weak magnetic fields resulting from the chemical reaction that occurs in corroding metal, offering substantial benefits for companies such as petroleum producers, which rely on extensive networks of pipelines. A new subsidiary, Quantum Magnetics, is preparing laboratory and industrial versions. An introduction date has not yet been announced.

Both Biomagnetic's medical-imaging product and Quantum's rust monitor rely on the superconducting quantum interference device (SQUID), which consists of two Josephson junctions. This exquisitely sensitive detector can pick up magnetic fields a billion times weaker than the

Niobium electronics

1987 SIZE: $40 million

PLAYERS: ASEA-Brown Baveri, Biamagnetic Technologies, Cryagenic Consultants, Fujitsu, General Electric, General Electric (England), Hypres, Matsushita Electric Industrial, Mitsubishi Electric, NEC, Nippan Telegraph & Telephane, Quantum Design, Sumitama, Toshiba, TRW, Westinghouse Electric

LOGOS BY JAVIER ROMERO

High Technology Business' Guide to Superconducting 1988

The following directory lists the 48 companies active in superconductor research and sales around the world. Alphabetical listings within categories—United States, European, Japanese, or startup companies—represent the full spectrum of superconductor activity, from small entrepreneurs to large corporations doing small-scale research to major players already profiting from this growing technology. The list includes all companies our researchers could find, no matter how significant or insignificant their current programs may appear.

THE U.S. COMPANIES

COMPANY	OFFICERS	FINANCING	STAFF (SUPERCONDUCTING)	SUPERCONDUCTOR ACTIVITY
1. American Magnetics Box 2509 Oak Ridge, TN 37831 (615) 482-1D56	Kenneth Efferson, president Robert Joke, v.p., general manager E.T. Henson, v.p., morketing ond sales	Privately owned; sales of $1 million to $5 million	2D	8uilding custom niobium superconducting magnets and instruments for research use; pursuing the specioity-magnet morket.
2. AT&T Bell Lobs/Bell Communicatians Research (Bellcore) 600 Mountoin Ave. Murray Hill, NJ 07974 (2D1) 582-3000	Robert Dynes, director, chemical physics research Donold Murphy, head of solid-state chemistry research Paul E. Fleury, director, physicol research lob	AT&T subsidiaries; Bell Lobs has on onnual budget of $2.25 billion, 1D percent dedicated to basic research	4D	In superconductivity research since 1950; developed niobium olloys, did early work on Josephson junctions. Mode mojor contributions to the discovery of high-temperature ceramic superconductors. Currently pursuing basic research.
3. Bechtel National Box 3965 Son Froncisco, CA 94119 (415) 768-1234	Robert J. Loyd, project manager, Superconducting Magnetic Energy Storage (SMES)	Privately held; soles of $14D million. SMES contract worth more than $1D million	6 (more expected in early 1988)	Developing SMES os port of the Strategic Defense Initiative; may use experience to enter commerciol utility morket.
4. Biomagnetic Technolagies 4174 Sorrento Valley 8lvd. Son Diego, CA 92121 (619) 453-6300	Stephan O. Jomes, president, CED William C. Block, senior v.p. Eugene Hirschkoff, v.p., operations	Privately held. Roised $5.2 million in first-round finoncing in 1985, $4.2 million in second round, 1987. Projected 1987 revenues, $3.7 million	85	Morketing SQUIDs ond related equipment, including its Neuromagnetameter for observing brain functions. Seeking portnership with medical-equipment company to sell ond support products.
5. E. I. Du Pont de Nemours 1007 Market St. Wilmington, DE 19898 (3D2) 774-1000	Edword Mead, monager, superconductor business development Rudolph Pariser, director, advanced materials research Arthur W. Sleight, research leader	Listed on New York Stock Exchange. 1986 earnings, $1.1 billion; soles, $29.4 billion	3D	Attempting to opply its expertise in chemicol processing to the lorge-scale production of superconductors. Wants to supply high-temperature superconductor markets as they emerge.
6. Energy Canversion Devices 1675 W. Maple Rd. Troy, MI 46084 (313) 26D-1900	Stanford R. Dvshinsky, president, CEO Stephen J. Hudgens, v.p., R&D Roso T. Young, sr. scientist, group leader	Troded on NASDAQ. Fiscal 1986 net loss of $27.9 million on revenue of $21.1 million; superconductivity work internolly funded ot $1 million	Abaut 1D	Studying ceramic and niobium-based superconductors. Developed a process for mixing fluaride with ceromic for higher-temperature superconductivity, but process not independently verified. Plans to license fluorination technolagy if o morket develops.
7. Eriez Magnetics/Eriez Manufacturing Asbury Road at Airport Erie, PA 16514 (814) 833-9881	Chester F. Giermok, president Jerry Selvaggi, consultont/engineering monager	Privotely held; $4D million in sales	10	Designed and installed the first superconducting magnet for industriol use, o seporator that removes impurities from cloy. Plans to compete with conventionol seporators that remove porticles from wastewater.
8. Ford Motor 8ox 1899 Dearborn, MI 48121 (313) 322-3000	John McTague, v.p., research Marga Roberts, director, chemistry ond physicol sciences Craig L. Davis, manager, physics dept.	Troded on New York Stock Exchange. 1986 earnings of $3.3 billion on sales of $62.7 billion	5	Working with Detroit's Woyne State University on high-temperoture superconductors. Looking for electronic opplications that would be pursued by its Aeronutronic Division in Newport 8each, Colif.
9. GA Technologies/Applied Superconetics Box 85608 Son Diego, CA 92138 (619) 452-3400	Tihiro Dhkawo, vice chairman Kenneth Partain, president, Applied Superconetics John Alcorn, manager, Superconducting Mognet Group	Privotely owned; 1986 soles of $154 million	100	Designing ond building speciolized magnets. GA's subsidiary, Applied Superconetics, sells mognets for use in mognetic-resononce imaging. Strong condidate to supply magnets for the Super Collider.

THE U.S. COMPANIES (Continued)

COMPANY	OFFICERS	FINANCING	STAFF (SUPERCONDUCTING)	SUPERCONDUCTOR ACTIVITY
10. Garrett Box 92248 Los Angeles, CA 90009 (213) 776-1010	Anil Trivedi, assistant manager, advonced opplications	Porent company, Allied-Signol, on New York Stock Exchonge; Garrett had 1986 soles of $2.15 billion	10 to 20	Developing a fine-grained superconductor ceromic pawder far electronics ond industrial use.
11. General Dynamics Space Systems Division 5001 Kearny Villa Rd. San Diego, CA 92123 (619) 573-8000	David Wolker, chief, R&D designs Robert Johnson, progrom monoger, energy programs	Traded on New York Stock Exchange. 1986 revenues, $8.9 billion; loss of $63 million due to $420-million write-off of purchase price of Cessna Aircraft	60 at peak; now only o few preparing propasals	Built lorge magnets for Department of Energy research progroms; may use expertise to supply magnets for the Super Collider.
12. General Electric Medical Systems Group Box 414 Milwoukee, WI 53201 (414) 544-3011	John Troni, sr. v.p., group executive Michael J. Jeffries, R&D manager, GE R&D Center	Troded on New York Stock Exchange. 1986 earnings of $2.5 billion on soles of $35.2 billion	20 at R&D Center; the Medical Systems Group employs several hundred	Supplying magnetic-resononce-imaging equipment. The R&D Center developed superconducting generators ond is working on high-temperature ceramic superconductars.
13. General Motors Technical Center 30200 Mound Rd. Worren, MI 48090 (313) 575-1188	Donold J. Atwood, vice chairman Robert Frosch, v.p., GM Research Loboratories	Traded on New York Stock Exchonge; 1986 earnings of $2.9 billion on earnings of $102.8 billion	5	GM Research Labs is developing ways to deposit thin films of ceramic superconductors on silicon wafers. Hos demonstrated a metallo-organic depasition technique that lays down films without the use of vocuum.
14. Hypres 500 Executive Blvd. Elmsford, NY 10523 (914) 592-1190	Sadeg M. Faris, president, CEO Gerald M. Hoines, v.p., CFO Eric Honson, v.p., praduct development	Privately held; venture funding of $2.2 million in August 1983 and $6.4 million in December 1985	75	Produces o commercial Josephson-junction microchip that it uses in electronic instruments. Plons to introduce more such devices; seeks partner to develop and market a computer.
15. IBM Watson Research Center Box 218 Yorktown Heights, NY 10598 (914) 945-3000	Prauveen Choudhari, v.p., physicol-science research Alex Molozemoff, coordinator, superconductivity progrom	Traded on New York Stock Exchange. 1986 earnings of $4.8 billion on revenues of $51.2 billion; 1986 R&D and engineering budget, $5.2 billion	Not ovoilable	Studying high-temperature materials to achieve superconductivity at room temperature.
16. Intermagnetics General Charles Industriol Pork Box 566 Guilderland, NY 12084 (518) 456-5456	Corl Rosner, choirman, president C. Richard Mullen, sr. v.p., operations Bruce A. Zeitlin, v.p., materials technology	Troded on NASDAQ. Lost $3.9 million on revenues of $14.3 million in 1987; 1986 profit of $1.6 million on revenues of $21.2 million	More than 300, including production workers	The leading U.S. moker of wire and coble, ond magnets for commercial and research markets. Saw 1987 loss after its lorgest customer, Johnson & Johnson, discontinued product line. Positioned to be leading supplier of magnets for the Super Collider.
17. Microelectronics and Computer Technology 3500 W. Bolcones Center Dr. Austin, TX 78759 (512) 343-0978	Gront A. Dove, chairmon, CEO Borry Wholen, v.p. Horry Krager, technical director, packaging ond interconnects	Owned by consortium; $75-million operating budget	7	Coordinates research effarts of electronics companies that own it. Developing high-temperature superconductors for electronics packoging ond interconnects. Seeking new participants.
18. Quantum Design 11578 Sorrento Volley Rd. San Diego, CA 92121 (619) 481-4400	Williom B. Lindgren, president, generol monoger Michael B. Simmonds, v.p.	Privately held; recently topped $1 million in onnuol soles	22	Making instruments that measure magnetic properties, using SQUIDs from Biomagnetics Technolagies. A subsidiary, Quontum Magnetics, will morket additionol SQUID-based instruments, including a rust detector.
19. Supercon 830 Boston Turnpike Rd. Shrewsbury, MA 01545 (617) 842-0174	James Wong, president Eric Gregory, v.p., general manager	Privately held; annual sales of $1 million to $5 million	30	Monufacturing niobium-alloy wire and coble. Supplies research lobs, GE, and GA Technalogies. Maneuvering ta supply the Super Collider.
20. Teledyne Wah Chang Albany Division Box 460 Albony, OR 97321 (503) 926-4211	Al Riesen, president Chet Leroy, v.p., technology	Troded on New York Stock Exchonge. Earned $129 million on sales of $1.6 billion for the first half of 1987.	10 in R&D; many more in production	Leading supplier of niobium-olloy wire for mognets made by companies including Oxford, Intermagnetics, ond Supercon. Plans to be major supplier of wire for magnets in the Super Collider.
21. TRW 1 Space Park Redondo Beach, CA 92077 (213) 535-4321	Williom Simmons, director, group research Arnold Silver, head, superconducting electronics	Traded on New York Stock Exchange. 1986 earnings of $217 million an sales of $6.4 billion	About 20	Researching Josephsan-junction circuits for the Defense Department. Will develop products for military ond aerospoce markets.

COMPANY	OFFICERS	FINANCING	STAFF (SUPERCONDUCTING)	SUPERCONDUCTOR ACTIVITY
22. Westinghouse Electric Research and Development Center 1310 Beulah Rd. Pittsburgh, PA 15235 (412) 256-1352	John Hulm, director, research Richard D. Blaugher, manager, cryogenic technology and electronics Alex Braginski, manager, superconducting materials	Traded on New York Stock Exchange. 1986 earnings of $671 million on revenues of $10.7 billion	7	Researching high-temperature ceramic superconductors; developing Josephsan-junction technology for the Air Force. Well positioned to be a major magnet supplier for the Super Collider. Superconducting generator technology may interest the Navy.

THE STARTUPS

COMPANY	OFFICERS	FINANCING	STAFF (SUPERCONDUCTING)	SUPERCONDUCTOR ACTIVITY
23. American Superconductor 21 Erie St. Cambridge, MA 02139 (617) 499-2600	George McKinney, president Terry Loucks, v.p., technology Francis Hughes, treasurer	Privately held; $4.35 million from American Research & Development, Rothschild Ventures, and Venrock	4	Holds a license on on MIT process for making ceramic wire and tape; plans to open pilot plant in 1988 to produce wires and ribbons, windings for magnets, and passibly thin wires for electronics. Significant profits not expected for 7 to 10 years.
24. AppliTech of Indiana 8150 Zionsville Rd. Indianapolis, IN 46200 (317) 872-6109	N. Quick, founder	Privately held; financial data unavailable	4	Developing a process for making very high-quality ceramic; testing a laser process for eliminating flaws. Pilot plant expected in two years.
25. Arch Development 1115-25 E. 56th St. Chicago, IL 60637 (312) 702-7417	Steven Lazarus, president, CEO Brion R.T. Frost, director, Technology Transfer Center, Argonne National Laboratory Janett Truhatch, associate v.p. for Research, University of Chicago	Nonprofit; funded by Argonne National Laboratory and University of Chicago	50 scientists and technicians at Argonne	Setting up a company to develop a way to make ceramic wire. Plans to license patents, form cooperative R&D partnerships, and create new companies.
26. Ceramics Process Systems 840 Memorial Dr. Cambridge, MA 02139 (617) 354-2020	H. Kent Bawen, chairman Clayton M. Christensen, president, director George A. Neil Jr., exec. v.p., operations	Common stock traded on NASDAQ. 1986 revenue, $2.6 million; net loss, $4.1 million	As many as 12	Developing metal-ceramic layered packages for integrated circuits. Wants to link marketing with other companies. Focusing on developing products that can be made using micro-smooth sheet forming, metal-ceramic laminates, and molding.
27. Conductor Technologies 1001 Connecticut Ave. N.W. Washington, DC 20036 (202) 452-0900	Stephen J. Lawrence, president Laurence Storch, v.p.	Privately held; undisclosed amount from private sources	None full-time	Supports the work of MIT researchers who are developing electronic devices made from ceramic superconductors; seeking priority in licensing resulting patents.
28. Conductus 2275 E. Bayshore Rd. Palo Alto, CA 94303 (415) 494-7836	John Shoch, president, CEO Tony Sun, CFO	$6 million in first-round financing	None full-time	Developing fabrication methods using thin-film techniques similar to those used to produce semiconductors. Exploring very high-speed digital devices, magnetic field detectors (SQUIDs) and other sensors, and high-speed electronic interconnections.
29. Electro-Kinetic Systems 701 Chestnut St. Tronier, PA 19013 (215) 497-4660	Jock Reilly, chairman, CEO Burton Lederman, director, R&D	Listed on NASDAQ. Sales of $2 million, earnings of $65,000	2	Developing ceramic-based materials that can be applied as coatings and which superconduct at liquid-nitrogen temperature. Working with MIT.
30. Guernsey Coating Labs 4464 McGrath St., Unit 106 Ventura, CA 93003 (805) 642-1508	Peter Guernsey, president Sam Pellicori, consulting physicist	Privately held; sales of $500,000 in optical coatings; seeking $500,000 in venture capital	1 part-time	An established optical-coating lab, diversifying into custom coating with ceramic superconductors.
31. Monolithic Superconductors Box 1654 Lake Oswego, OR 97035 (503) 684-2974	Lawrence E. Murr, owner, founder Alan Hare, owner, founder	Privately held; financial data unavailable	6	Developing a way to produce bulk ceramic material by using shock waves to bond particles. Seeking venture capital and cooperative research to help commercialize the technique.

THE JAPANESE

COMPANY	SUPERCONDUCTOR ACTIVITY
32. Fujitsu Marunauchi Building 6-1 Marunauchi, 1-chome Chiyoda-ku, Takya 100, Japan (03) 216-3211	Researching high-temperoture ceramics, with particular interest in thin films. Working an Josephsan junctians ta develop a superconducting computer.
33. Furukawa Electric 2-6-1, Marunouchi Chiyoda-ku, Takya 100, Japan (03) 286-3001	Major electrical cable maker; developing a ceramic-based, ring-shaped superconducting magnet.
34. Hitachi Central Research Labaratary Kakubunji, Takya 185, Japan 0423-23-1111 x 3217	Leading developer af niabium-based Josephson junctians. Alsa developing ceramic-based superconductars far electranics. Hitachi Cable division makes niabium-based wire.
35. Kawasaki Steel 2-2-3, Uchisaiwaicha Chiyoda-ku, Takya 100, Japan (03) 597-3111	Developing an experimental superconducting wire made af ceramic.
36. Matsushita Electric Industrial 1-1-2, Shibakoen Minata-ku, Takya 105, Japan (03) 437-1121	Warking an ceramic thin films far silican wafers, passibly leading ta a process that uses superconductars in integrated circuits.
37. Mitsubishi Electric 2-2-3, Marunauchi Chiyoda-ku, Takya 100, Japan (03) 218-2111	Researching superconductivity since 1958; experimenting with ceramic-based, high-temperature materials. Makes superconducting tape.
38. NEC 5-33-1, Shiba Minata-ku, Tokyo 108, Japan (03) 454-1111	Researching Jasephsan-junctian technalagy far computers and ather electranic applications.
39. Nippan Steel 2-6-3, Otemachi Chiyoda-ku, Takya 100, Japan (03) 242-4111	Developing ceramic-based, superconducting wire.
40. Nippan Telegraph & Telephone 1-6-1, Uchisaiwaicho Chiyoda-ku, Takya 100, Japan (03) 509-5035	Pursuing Japan's largest development effart in Jasephsan-junctian technalagy; alsa experimenting with techniques far producing ceramic crystals and films.
41. Sumitama Electric Industries 3-12-1 Mata-Akafaka Minata-ku, Takya 107, Japan (03) 423-5111	Has more than 400 Japanese patent applicatians in ceramic superconductars. Affiliate Sumitama Heavy Industries is building a superconducting synchotron, expected by 1989, ta etch chips.
42. Tashiba 1-1-1, Shibaura Minata-ku, Kawasaki 105, Japan (03) 597-7111	Developing experimental ceramic wire and tape by bonding superconducting pawders inside a metal capillary.

THE EUROPEANS

COMPANY	SUPERCONDUCTOR ACTIVITY
43. ASEA-Brown Baveri S-721 83 Vafteraf, Sweden 021-10 00 00	Researching high-temperature supercanductars far use in high-pawered magnets and generatars.
44. Cryagenic Consultants Metrastare Building 231 The Vale Landan W3 7QS, England 01-743-6049	Designing and manufacturing superconductar and superconductar-caaling equipment, including magnets far research, mineral separatars, SQUIDs, and related electranic devices.
45. General Electric 1 Stanhope Gate Landan W1A 1EH, England 01-493-8484	Makes magnetic-resonance-imaging equipment with magnets from Oxford Instruments. Researching high-temperature superconductars far use in large magnets, electrical machiners, and electranics.
46. Oxford Instruments Group Eynsham Oxford OX8 1TL, England (0865) 881-437	Has about 50 percent market share in magnets far magnetic-resonance imaging; alsa makes niabium-allay wire and cable. Expected ta became major supplier af wire and cable far magnets used in the Super Callider.
47. Plessey Vicarage Lane Ilford, Essex IG1 4AQ, England 01-478-3040	Developing ceramic superconductars; studying applicatians in electric-pawer cables, Jasephson-junction circuits, SQUIDs, and thin films.
48. Siemens Wittelsbacherplatz 2, Muenchen Postfach 103, D-8000 1 Federal Republic af Germany (089) 234-10	A leading builder af superconductar magnet systems and magnetic-resanance imaging equipment. Developing test magnets far medical market.

earth's. Almost all electronic uses for superconductors involve SQUIDs.

For instance, the Defense Department buys SQUIDs, primarily from TRW, Westinghouse, and General Electric. The Navy is studying SQUIDs as submarine detectors, and the devices are also being used in the Terahertz Initiative, an offshoot of the Strategic Defense Initiative that seeks to develop Josephson-based technology for radar and communications. However, this effort has a modest $4-million budget.

Niobium rods, wires, and cable. The $10-million annual supply line for rods, wires, and cable provides the basic electrical conductors used in superconducting magnets. Teledyne Wah Chang is the industry's chief producer of niobium-alloy rods. It sells them to wire-fabrication houses—mainly Intermagnetics General, Oxford Instruments, and Supercon—

which pull the rods to produce wire, which in turn may be wound into cable. New England Wire & Cable specializes in making cable only, from wire supplied by other companies.

Even though these companies have a relatively stable footing, technical innovation is still the key to market dominance. Competitive development centers on niobium-tin compounds, which show the best commercially available superconductivity properties, but which have been too brittle for practical use. Intermagnetics General has experimentally produced continuous, thin strands 90,000 feet long. Also, the company's "internal tin" multifilament conductor, which relies on particles of the compound rather than continuous strands, is fast becoming an industry standard.

Small niobium magnets for research. Last year, companies spent about $10 million on small, custom-made niobium magnets for experiments. This research seeks to find new uses for magnets and to improve existing uses.

Major suppliers to this market are Intermagnetics General and Oxford Instruments. But the field also includes GA Technologies, American Magnetics, and Cryogenic Consultants.

Promising new uses for this research include:

■ X-ray lithography, a largely experimental method for creating more finely detailed computer chips than can be made with established technology. Superconducting magnets steer intense X-ray beams that lay down microscopic circuit patterns. Oxford Instruments, in a three-year, $15-million effort for IBM, is building a prototype of such a device.

Small niobium magnets for research

1987 SIZE: $10 million

PLAYERS: American Magnetics, ASEA-Brown Boveri, Cryogenic Consultants, Eriez Magnetics, GA Technologies, Hitachi, Intermagnetics Generol, Oxford Instruments Group, Siemens, Sumitomo, Toshibo

■ Powerful industrial magnets made from superconductors. These magnets could be used to treat wastewater or remove impurities from oil or coal. Eriez Magnetics, aided by GA Technologies and Cryogenic Consultants, recently sold a $2-million prototype superconducting magnetic separator to J.M. Huber Corp. of Wrens, Ga., which will use it to remove impurities from clay. The product's liquid-helium cooling system is computer controlled, so Eriez claims the system requires no special skills to operate. Thus the prototype demonstrates that niobium superconductors may have a future in standard industrial settings.

■ Improved medical imagers. Already the largest single use for superconductors by a wide margin, these devices will yield better results if stronger magnets can be produced. The West German company Siemens has built an experimental magnet with more than twice the strength of those used today, and Oxford Instruments is building similar test magnets.

Niobium rods, wires, and cable

1987 SIZE: $10 million

PLAYERS: ASEA-Brown Boveri, Furukawa Electric, Intermagnetics Generol, Mitsubishi Electric, Oxford Instruments Group, Supercon, Teledyne Wah Chang

R&D of niobium materials. As last year's headlines touted ceramic superconductors, Teledyne Wah Chang quietly developed a more homogeneous form of the compound niobium titanium, the basic material for superconducting wire and cable used in magnets. This new form generates stronger magnetic fields when charged with an electric current, and therefore is being applied to development of the Superconducting Super Collider.

Such work makes Teledyne the clear leader in this activity. It is developing another promising compound, niobium tin, which produces even stronger magnetic fields while retaining its superconductivity even through brief temperature increases. The compound is unpopular because it is brittle, but Teledyne Wah Chang is working on improved versions.

Teledyne's niobium research funding of about $1 million is relatively modest. But as the Super Collider work illustrates, the potential payback can be huge, because such metallurgical advances may quickly find commercial use in high-strength magnets.

R&D of niobium materials

1987 SIZE: About $2 million

PLAYERS: Energy Conversion Devices, Intermagnetics Generol, Supercon, Teledyne Woh Chang

Large niobium magnets for energy programs. The general slowdown in U.S. energy programs effectively curtailed market activity for large niobium magnets in 1987. Earlier, both General Electric and Westinghouse had worked on superconducting electric generators, and the Department of Energy bought large niobium magnets for its fusion-energy development program.

According to analyst C.B. Whichard predicts that Business Technology Research, large niobium magnets for storing electricity represent the most promising large-scale application for the near term, because they offer electric utility companies a way to store energy for peak load periods. In 1986, Bechtel, GA Technologies, and General Dynamics, work-

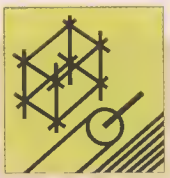
Large niobium magnets for energy programs

1987 SIZE: Negligible

PLAYERS: Bechtel National, Eriez Magnetics, Garrett, General Dynamics, Hitachi, Mitsubishi Electric, Sumitomo, Toshiba

ing with Los Alamos and Lawrence Livermore Laboratories, demonstrated the feasibility of such devices. Although the market does not yet exist, Whichard predicts that it may grow to between $50 million and $100 million by 1997. He expects General Dynamics to emerge as the leader in this field.

The market for large magnets could stir as early as this year. Intermagnetics General and General Dynamics have fabricated test magnets for the Super Collider, demonstrating that the government's demanding designs can be met by private industry. Also, electric-energy storage systems for the Strategic Defense Initiative are growing into another new market. A dominant player is GA Technologies, which has built a powerful magnetic coil to store and rapidly release electricity for the Air Force-sponsored High-Voltage Homopolar Generator experiment at the University of Texas at Austin. Bechtel International recently won a contract to build a much larger energy-storage system for the Defense Nuclear Agency.



Ceramic wires and tapes

1987 SIZE: None

PLAYERS: Americon Superconductor, Arch Development, ASEA-Brown Boveri, AT&T Bell Labs/Bellcore, Conductor Technologies, Fujitsu, Furukawa Electric, General Electric (Englond), IBM, Kowosoki Steel, Mitsubishi Electric, Monolithic Superconductors, Nippon Steel, Sumitoma, Tashiba

R&D of ceramic materials. Although many companies in the superconductor industry have great expectations for high-temperature ceramic materials, they are still plagued by two problems. Superconducting ceramics are very brittle and hard to work with, and they cannot carry large electrical currents, which is the key to generating strong magnetic fields.

Several companies are working to improve the current-flow of ceramic superconductors, but with limited success. IBM and Nippon Telegraph & Telephone (NTT) have made very thin films, a micron or less in thickness, with current capacities comparable to niobium alloys. However, the usefulness of such films as bulk current-carriers is very doubtful.

R&D of of ceramic materials

1987 SIZE: None

PLAYERS: Applitech of Indiana, ASEA-Brown Boveri, AT&T Bell Labs/Bellcore, Ceramics Process Systems, Du Pont, Energy Conversion Devices, Ford, Fujitsu, Garrett, Generol Electric, General Electric (England), IBM, Misubishi, Nippon Telephone & Telegroph, Plessey, Sumitomo, Supercon, Teledyne Wah Chong, Westinghouse Electric

As a result, materials research increasingly focuses on learning more about the properties of ceramics' high-temperature superconductivity. Because of its hefty cost, such fundamental research will remain primarily with large companies, including IBM, AT&T Bell Labs, and NTT in Japan. In addition, Du Pont is working on techniques for large-scale production of superconducting ceramics.

Nevertheless, small companies with a novel technology can find a place among the giants. For example, Energy Conversion Devices is in the forefront of materials research with a process for replacing some of the oxygen in a ceramic with fluorine. Tests show that this raises the superconducting temperature.

Ceramic wires and tapes. Wires and conducting tapes are essential if ceramic superconductors are to become useful products. Therefore a number of companies are attacking this problem, including the startup Arch Development, plus IBM and AT&T Bell Labs, and the overseas companies ASEA-Brown Boveri, General Electric (England), Fujitsu, Hitachi, Furukawa, Mitsubishi, Sumitomo, and Toshiba. The startup American Superconductor appears to be closest to delivering a commercial product.

American Superconductor makes flexible ribbon from superconducting materials by mixing them with molten silver, then putting the mixture onto a chilled, spinning wheel. The molten metal rapidly solidifies and rolls off the wheel as continuous ribbon. Backed by $4 million in venture-capital funding, the company is now running a pilot plant and plans to begin selling its superconducting tape early this year. However, skeptics such as IBM researcher Paul Grant point out that, as of late last year, American Superconductor had not yet produced even laboratory samples that can do what it claims its production tapes will.

At Arch Development, a joint venture of Argonne National Laboratory and the University of Chicago, researchers mix ceramic powder with a binder and form it into thread-like fibers that can be wound into wire before heat treatment turns the powder into a superconductor and makes it brittle. AT&T Bell Labs uses a similar approach to make flexible tapes. Toshiba encapsulates ceramic powder in a metal tube that can be formed into wire or tape before heating.

Ceramic coatings, thin films, and electronics. Ceramics can easily be formed into coatings and thin films that can be processed with standard microelectronic-fabrication techniques used to make silicon chips. Indeed, ceramic coating processes are so straightforward that AT&T Bellcore, which has demonstrated thin-film deposition using lasers, declines to patent its technique.

Because applying coatings is a relatively simple process, small companies that want to explore the technology are having trouble raising the money needed for research and development. For instance, Guernsey

Ceramic coatings, thin films, and electronics

1987 SIZE: None

PLAYERS: AT&T Bell Labs/Bellcore, Ceramics Process Systems, Conductor Technologies, Conductus, Electro-Kinetic Systems, Energy Conversion Devices, Garrett, General Electric (England), Generol Motors, Guernsey Coating Laboratories, IBM, Motsushita Electric Industriol, Microelectronics ond Computer Technology, Nippon Telegraph and Telephone

Coating Labs, an optical-coating company in Ventura, Calif., has been unable to attract venture dollars to support basic research in superconductor coatings. Venture capitalists are willing to back only proprietary techniques. However, president Peter Guernsey complains that, without research funding, the company cannot develop a proprietary process.

Ceramic coatings already have been used to produce electronic devices such as SQUIDs in laboratories by IBM, AT&T Bell Labs, Matsushita, NTT, and Energy Conversion Devices. But many technical difficulties remain. For example, ceramic SQUIDs are as much as 1,000 times less sensitive than their niobium counterparts.

Microelectronics & Computer Technology, which is setting up a consortium of 20 companies to support superconductor-electronics research, is studying the use of ceramics not in chips, but in electronic interconnects that would tie conventional computer chips together. Superconducting ceramics would provide much faster signal transmission between chips in a multiple-chip device.

JOAN SEIDEL

Led by entrepreneur George McKinney, American Superconductors aims to be first with new ceramic products.

In yet another attempt to apply superconducting ceramic to electronics, Electro-Kinetic Systems is developing coatings that would provide electronic shielding for computers. The coating would absorb signals generated by the computer which, when picked up by an outside receiver, can be deciphered to reveal its computations—a threat to security. Electro-Kinetic is developing a shield for the ETA-10 supercomputer from ETA Systems of St. Paul, Minn. The computer already uses liquid nitrogen to chill its circuitry, setting up the perfect environment for ceramic superconductor coating. Because of this synergism, shielding is expected to be one of the earliest commercial products for the new ceramics.

Research into uses for ceramic superconductors. The major electrical companies, plus nonprofit organizations such as the Electric Power Research Institute in Palo Alto, Calif., are studying potential applications for ceramic superconductors. These include magnetically levitated trains, long-distance power transmission, and superconducting motors and generators. However, such research isn't expected to bear fruit before the year 2000, if then.

Nitrogen-cooled superconducting wires or tapes, with properties that can compete with established niobium alloys, are needed to get such work beyond the early stages. So far, developments have not been promising. Wire made by Arch Development and Toshiba, for example, shows only poor current capacity and magnetic strength. George McKinney, president of American Superconductor, says he will sell a ceramic-based tape with high current capacity and a strong magnetic field early this year.

The most significant breakthrough for commercial superconductivity—for the near term at least—is not the discovery of high-temperature superconducting ceramics. More immediate payback is likely to come from developments such as Eriez' clay-purifying magnet, which demonstrates that superconductors can be applied to ordinary industrial tasks, and from Biomagnetic Technologies' medical imager.

The ceramic superconductivity community remains in a state of vigorous research activity, helped by federal funding and venture capital, but its present market prospects are rather cool. Unless researchers can overcome the technical difficulties, 1987's springtime of hope for ceramic superconductors may give way to a long winter of discontent. ■

Research into uses for ceramic superconductors

1987 SIZE: None

PLAYERS: ASEA-Brown Boveri, Garrett, General Electric (England), Mitsubishi Electric, NEC, Nippon Steel, Oxford Instruments Group, Sumitomo, Toshiba

T.A. Heppenheimer is a journalist and author specializing in aerospace and other technologies.

Equipment Makers Profit From Safer Skies

A proposal to put anticollision devices in all airliners could mean a bonanza for the companies that make them

BY RICHARD WOLKOMIR

FLYING IS becoming a series of narrowly averted disasters. Last year, the Federal Aviation Administration recorded 828 near-collisions between aircraft, a new high. Last August, even President Reagan unwillingly played aerial chicken as he flew to his California ranch aboard a Marine helicopter, when a Piper Archer buzzed just 150 feet below. The FAA predicts that, without new safety measures, continued increases in air traffic will increase the risk of airliner collisions 300 percent over the next two decades.

To cut the risk, the FAA plans to mandate that, within the next five years, all airliners carry cockpit alarms that warn pilots of impending collisions. For the two companies developing the equipment—Bendix Avionics and Sperry Dalmo Victor—the regulation should bring big profits, and other avionics companies will probably jump in later. The market is tempting: perhaps $720 million for the initial round of installations. Meanwhile, for passengers who value their necks over a potential few extra bucks per ticket, the new technology offers balm for troubled spirits.

"I flew in a 727 equipped with an advanced version of one of these devices, and it worked dandy," says Fred George, a former Navy fighter jockey and licensed commercial pilot who is West Coast editor for *Business and Commercial Aviation* magazine.

Major airlines also are enthusiastic about the equipment. "This technology is right at the top of the airline industry's safety objectives, and it has been for a number of years," says Roger Fleming, senior vice president for technical services at the Air Transport Association in Washington.

As far back as 1955, the Air Transport Association began pressing for a collision-avoidance system. Industry and the military tinkered with the concept throughout the 1960s. In the 1970s, the FAA contracted with MIT's Lincoln Laboratory in Bedford, Mass., to develop a model. Mitre Inc., of McLean, Va., created the system's software heart. Developed under a federal contract, the basic technology is public.

The result is called the Traffic Alert and Collision Avoidance System (TCAS). On a TCAS-equipped aircraft, a microwave receiver-transmitter (a transponder) "interrogates" transponders on nearby aircraft. The replies, coupled with radar data, enable the TCAS computer to determine the other planes' position, course, and altitude. Then the computer determines whether an in-flight collision is imminent.

The simplest version, the TCAS-I for smaller planes, simply warns pilots that another aircraft is threatening. TCAS-II, made for larger planes, warns pilots that they are on a collision course and tells them whether to stay on course, climb, dive, or stop climbing or diving. Airline pilots prefer the still-experimental TCAS-III; in addition to recommending climbs or dives, it advises on left or right turns.

TCAS-II is now undergoing flight tests. In September 1984, the FAA issued a contract to the Bendix/King Avionics Division of Allied Signal Inc. to develop a working model for the airline industry. In November 1984, the FAA awarded a matching contract to Sperry Dalmo Victor Inc., which is jointly owned by Unisys and the Bell Division of Textron Inc. Since March 15, 1987, a prototype Sperry TCAS-II has seen regular service aboard a Piedmont Airlines 727. Each company is readying seven production-stage systems for testing in regular service; the Bendix units will go aboard United Airlines 737s and DC-8s, and Sperry's will go on Piedmont 727s and Northwestern MD80s.

"Estimating from the size of the existing fleet and projecting the fleet's size over the next five years, along with

JOSE CRUZ/PUSHPIN

foreign carriers apt to be involved, the marketplace for TCAS equipment is $1.2 billion to $1.6 billion," says Paul Gralnick, general manager of Bendix/King's air-transport avionics division.

The FAA solicited public comment on the proposed rules last year, and unless they are modified, the rules will go into effect in 1988. They will require all airliners with more than 19 seats to carry TCAS-IIs within three years (turbine-powered planes have four years), and planes with 10 to 19 seats must install TCAS-I systems within five years. In other words, probably by 1993, every airliner in the country, and airliners of other countries using U.S. airspace, will have to carry some sort of TCAS.

"There are 3,000 to 4,000 airliners in the United States, depending on who is required to install the equipment," says Roger Fleming of the Air Transport Association. "We estimate that each TCAS-II will cost about $120,000, and that when you add installation and training, the total cost will be about $180,000 per airplane."

For regional airlines that fly smaller, less profitable planes, such figures are formidable. "We're in favor of anything that will improve safety, but we do have concerns," says Deborah Ladomirak, vice president and director of public affairs of the Regional Airline Association. "It has the potential of grounding a lot of equipment, with a serious impact on passengers."

Regional airlines are particularly concerned about a bill currently working its way through Congress, HR-1517, that would mandate TCAS-II on all aircraft with 31 or more seats. "We'd like to see the break not in terms of seats, but propellers versus jets, with prop planes getting TCAS-I and jets get-

ting TCAS-II, because it's hard to justify TCAS-II on an aircraft that costs only $6 million," says Ladomirak.

Aviation editor George believes the regional airlines will be hurt less than they fear: "It isn't likely the government is going to simply crush airlines with a regulation like this and drive them out of business."

Bendix estimates it will charge about $125,000 for a production-model TCAS-II, depending on the configuration the airline selects, says Maryellyn Horgan, the company's public relations manager. Estimates for the price of a TCAS-I range from $15,000 to $20,000. TCAS-III prices have not yet been estimated, but both Sperry and Bendix are designing their TCAS-II systems for easy upgrading to TCAS-III.

At the moment, Bendix may have a competitive edge. Sperry met the government's minimum standards for directional antennae accurate to within nine degrees; Bendix's antennae are accurate to within three degrees. That means the Bendix system should more accurately assess target aircrafts' bearings, minimizing unnecessary avoidance maneuvers. Meanwhile, aviation rumors say other players will eventually join the game. Thomas Williamson, an FAA electronics engineer working on TCAS, says companies have discussed manufacturing TCAS equipment with the FAA, but will not reveal their names. Rockwell International's Collins Avionics Division acknowledges that it plans to enter the market eventually. "We're waiting to see what rules the FAA finally approves," says Collins spokesperson Mari Schneider.

ACEY HARPER/PICTURE GROUP

Bendix's Paul Gralnick stands inside the company's unique TCAS test chamber.

"Due to the size of this market, there's a possibility that others will enter," says Bendix's Gralnick. "But there are barriers to early entry. For one thing, this equipment needs to be extensively tested. It's not a permanent barrier to entry. But if we and Sperry are as effective as we expect, the bulk of the retrofit market will be tied up. Even so, for two companies to provide all this equipment in a short period will not be easy."

Foster Air Data of Columbus, Ohio, is developing an alternative technology for the Navy. "The Navy training command is launching 200 airplanes at a time at bases like Pensacola and Corpus Christi—it's a hazardous situation and sometimes you have collisions and people die," says George Foster, founder and chairman of Foster Air Data. To solve the Navy's air-traffic problem, his company is developing a passive collision-avoidance system, as opposed to the active TCAS approach.

TCAS-equipped aircraft directly interrogate each other. By contrast, Foster's system eavesdrops on interrogating

THE COMPANIES TO WATCH

COMPANY	FOUNDED	1986 REVENUES	MAJOR PRODUCTS	MARKETS
Allied Signal Bendix/King Avionics Div. 2100 N.W. 62nd St. Fort Lauderdale, FL 33309 (305) 928-2100	1985	$4.6 billion for Allied Signal (division revenues not available)	Avionic systems, subsystems, and components	Defense, government, and industry involved in space and aviation
Foster Air Data Systems 7020 Huntley Rd. Columbus, OH 43229 (614) 888-9502	1972	$3 million—$5 million	Air-navigation systems, including Loran, short-range, and long-range NAV systems	General-aviation and commuter airlines; nontactical military markets (training and support)
Rockwell International Collins Avionics Div. 400 Collins Rd., N.E. Cedar Rapids, IA 52498 (319) 395-1000	Rockwell, 1928; Collins, 1933	$12 billion for Rockwell (division revenues not available)	Electronic and electromechanical flight-instrument systems, autopilots, flight-management equipment, transponders, weather radar, electronic caution systems	Any airplane owner, from private pilots to major airlines to military
Sperry Dalma Victar 21111 N. 19th Ave. Phoenix, AZ 85027 (602) 869-1234	1983	None	TCAS, transponders	None at present; projected sales to airlines

HOW PLANES CAN AVERT DISASTER

In the cockpit of a commercial airliner, somewhere over the United States, a synthesized computer voice cries "TRAFFIC! TRAFFIC!" Glancing at a screen that shows the sky marked off into sectors, the pilots see a symbol giving the location of another airplane. Meanwhile, the computer monitors the threatening plane's flight path, determining a course of action.

"CLIMB! CLIMB!" the voice orders, and the pilots comply. At the same time, the other aircraft's pilots hear a similar voice: "DESCEND! DESCEND!" If the situation warrants, the voice could also tell either plane to maintain its flight path, or to stop climbing or descending. Lights on the control panel also signal the command.

Once the planes have successfully avoided each other—only 45 seconds may have elapsed—the relieved pilots hear, "ADVISORY CLEAR! ADVISORY CLEAR!"

This is how the system about to be mandated by the FAA would work. The heart of the Traffic Alert and Collision Avoidance System (TCAS) is a computer about the size of a toaster oven. The unit connects to a directional radar antenna atop the airplane's fuselage. This antenna scans for other aircraft, feeding information to the computer so it can calculate their position and course.

The plane also carries a transponder, which receives and transmits microwave signals. TCAS-equipped planes can interrogate the transponders in other aircraft by using a blade antenna. The TCAS computer receives the identifying code, altitude, and bearing of all transponder-equipped aircraft in its vicinity.

The TCAS computer digests the data and determines if any aircraft are on a possible collision course with its own plane. If it detects a threat, the computer alerts the pilots.

Under development is a more sophisticated system, the TCAS-III, which uses extra directional antennae and a beefed-up computer program to give pilots more specific instructions, such as orders to turn right or left.

signals sent from air-traffic control radar on the ground to aircraft in the area. By listening in, computers on each Foster-equipped aircraft can calculate the altitude, bearing, and speed of other aircraft, thus determining collision threats.

Foster says the Navy is interested in his passive design because 200 planes interrogating each other in a small area, TCAS-style, would overwhelm the system with signals. The military market, he says, is about $200 million. However, he believes that intensifying air traffic over major U.S. cities ultimately will make his system necessary for civilian use as well.

"The FAA has about $100 million in the TCAS program, so they're protective of their past judgment," he says. "We're not adversaries of the FAA. We're just demonstrating the practicality of this other technology."

But the Foster approach has drawbacks. "The FAA isn't opposed to the passive system, as long as you could show it would provide the same level of protection as the active system," says the FAA's Williamson. "But a jet out over the Atlantic flies beyond the range of ground radar. The passive system would work over land, and it's cheaper, but it wouldn't work 150 miles off the coast."

TCAS is designed to operate in traffic as thick as 0.3 aircraft per square mile—the equivalent of 15 aircraft within a four-mile radius—at all altitudes. Over Los Angeles, the nation's most crowded airspace, aircraft density reached 0.26 during a February 1985 flight test of Bendix's TCAS-III system. However, TCAS is designed to minimize jamming from too many signals pulsing through the skies.

Even if density does reach or exceed the TCAS-II design limitations, it may be a minor problem. Both the Bendix and Sperry systems are easily upgraded to TCAS-III, which handles 0.4 aircraft per square mile. George says overcoming excess air-traffic density may be even easier: "We're talking about a system so software-intensive you can bang in a new board and get some hot-rod software and solve most of your problems."

Foster predicts the passive and active approaches eventually will be mated. Robert Green, senior marketing representative for Sperry Dalmo Victor, agrees. "After the 1990s or the year 2000, we'll upgrade the system, possibly to an active-passive combination," he says.

But in the meantime, like Bendix, Sperry Dalmo Victor is committed to producing TCAS-II systems as soon as federal regulations mandate the technology. Says Green, "We fully intend to be a supplier of TCAS-II and of TCAS-III as well, if it comes about."

TCAS-I has not yet been developed, but avionics engineers believe this simpler technology will present few problems. The proposed FAA rules demand it for turbine-powered airliners that carry 10 to 19 passengers, but it can be coupled with a standard Mode C transponder rather than the newer and more sophisticated Mode S type. Current estimates of the TCAS-I's cost are $15,000 to $20,000.

The proposed rules do not require TCAS for general-aviation aircraft, and small planes will not show up on the system if they do not carry the proper transponders. Prices for those transponders vary. For instance, Collins Avionics' Mode C transponders cost from $6,855 for corporate jets to $1,515 for single-engine propeller planes. Many private pilots might prefer to duck this expense, but ultimately they may have to bite the economic bullet. "We want TCAS, and we also want the transponders in general-aviation planes," says the Air Transport Association's Fleming.

Foreign airlines will almost certainly have to buy the full TCAS package. "The FAA would require TCAS in foreign jets, and there's no way they can afford not to install them, because of the liability," says Fleming.

Whenever the regulations become final, TCAS should provide a brisk business for avionics companies. In addition, profits should extend beyond the equipment itself.

Says Bendix's Gralnick, "The airlines' attitude is that some want it and some see it as an economic burden, but they all realize it's a forced march. They have to have this equipment." ■

Richard Wolkomir writes for several national magazines. In 1985 he received the American Association for the Advancement of Science/Westinghouse award.

THE HIGH TECHNOLOGY BUSINESS LEADING 100

COMPANY (SYMBOL)	RANK THIS MONTH/ LAST MONTH	PRICE INCREASE LAST MONTH (%)	CLOSING PRICE ($)	EARNINGS PER SHARE		LATEST DIVIDEND ($)	P/E RATIO	DEBT/ EQUITY RATIO	LATEST 12 MONTHS' REVENUE (IN MILLIONS)
				LAST QUARTER ($)	CHANGE FROM 1 YEAR AGO				
AEROSPACE									
Gull (GLL)	1/*	2.7	19.25	.11	-50.0	.05	19.8	1.05	69.3
Atlantic Research (ATRC)	2/2	.0	28.25	.60	53.8	—	13.6	.45	378.6
Gen. Matars H. (GMH)	3/9	-11.6	43.75	NA	NA	.72	NA	NA	NA
Singer (SMF)	4/1	-12.7	48.25	.69	-10.4	.40	24.7	.53	1,835.0
Raytheon (RTN)	5/*	-16.3	69.38	1.57	19.8	1.80	12.0	.02	7,564.2
McDannell Daug. (MD)	6/*	-16.5	63.88	1.98	88.6	2.32	8.3	.23	13,113.9
Rackwell Intl. (ROK)	7/*	-18.2	19.63	.61	13.0	.66	8.5	.20	12,382.7
Grumman (GQ)	8/*	-20.7	23.00	.18	-60.9	1.00	12.6	.58	3,296.8
Kaman A. (KAMNA)	9/10	-22.4	16.00	.36	24.1	.64	12.2	.55	681.5
Prec. Aeratech. (PAR)	1/*	-22.5	4.75	.11	-31.3	—	9.5	4.19	33.8
CHEMICALS									
Am. Callaid. (ACOL)	1/*	.0	19.00	.41	-29.3	—	12.7	.16	81.1
Essex Chemical (ESX)	2/*	-1.7	22.25	.02	-92.0	.60	29.7	.62	206.9
Spec. Camp. (SPCM)	3/*	-5.9	4.00	.11	22.2	—	18.2	.65	8.8
Hawkins Chem. (HWKN)	4/*	-8.7	5.25	.18	5.9	.09	10.7	.01	31.7
Free Mc. Rsc. (FRP)	5/*	-12.1	17.25	NA	NA	2.40	NA	NA	NA
Oakite Products (OKT)	6/*	-16.3	26.88	.76	33.3	1.52	12.9	.07	79.3
Aceta (ACET)	7/*	-18.6	12.00	.21	-57.1	.13	11.8	.08	97.7
MacDermid (MACD)	8/8	-19.1	27.50	.43	16.2	.52	16.6	.24	105.8
Intl. Flav. Frag. (IFF)	9/*	-22.0	43.38	.72	20.0	1.24	15.9	.00	712.3
Nuclear Metals (NUCM)	10/*	-22.8	11.00	-.85	-100.0	—	NE	.27	43.0
COMMUNICATIONS									
UC (UCX)	1/*	5.4	9.75	.15	-31.8	—	13.9	.55	102.9
NW Telecam. (NOWT)	2/4	1.2	21.00	.31	106.7	.92	11.5	2.88	41.1
BellSouth (BLS)	3/*	-3.6	39.88	.87	3.6	2.20	11.9	.56	11,921.3
Bell Atlantic (BEL)	4/*	-4.7	73.25	1.62	8.7	3.84	11.9	.60	10,297.8
Ameritech (AIT)	5/*	-5.8	89.00	2.15	6.4	5.00	11.0	.59	9,463.5
Equatorial Camms. (EQUA)	6/*	-5.8	3.06	-.18	NE	—	NE	.25	44.1
MCI Camms. (MCIC)	7/1	-6.9	10.13	.06	-50.0	—	NE	2.12	3,821.3
Bell Canada (BCE)	8/*	-7.5	27.63	.88	-12.9	2.40	NA	.80	14,729.1
Cinn. Bell (CSN)	9/*	-7.7	24.00	.43	-10.4	.96	12.7	.50	525.8
Nynex (NYN)	10/*	-8.0	71.50	1.63	5.2	3.80	11.6	.62	11,936.6
COMPUTERS									
Telex (TC)	1/*	1.8	56.50	1.02	-22.7	—	11.1	.28	876.9
Datasouth Cmptr. (DSCC)	2/*	.0	2.25	-.02	-100.0	—	NE	.00	17.5
Primages (PRIMC)	3/*	.0	3.75	.02	NE	—	NE	2.22	5.3
Audiatranics (ADO)	4/*	-8.0	1.38	-.29	NE	—	NE	.68	5.6
Ungermann Bass (UNGR)	5/*	-12.1	8.13	.11	57.1	—	23.2	.76	137.8
Lexican (LEXI)	6/*	-15.0	1.75	-.08	NE	—	9.7	.18	18.4
Printronix (PTNX)	7/*	-16.1	9.13	.11	NE	—	NE	.00	120.1
Datametrics (DMCZ)	8/*	-16.7	2.50	-.01	-100.0	—	83.3	10.00	21.5
ECC Intl. (ECC)	9/*	-17.3	10.75	.22	29.4	.20	13.6	.33	38.1
Dataram (DTM)	10/*	-17.7	6.38	.09	-62.5	—	19.3	.00	14.9
DRUG MANUFACTURERS									
VLI (VLIS)	1/*	6.9	5.88	-.02	NE	—	NE	.00	18.9
TechAmerica (TCH)	2/*	-3.4	3.75	-.12	NE	—	NE	.42	29.7
Merck (MRK)	3/*	-12.0	183.00	1.74	40.3	3.20	29.6	.07	4,816.0
Scher. Plough (SGP)	4/*	-12.8	47.50	.63	26.0	1.20	18.6	.20	2,635.9
Sterling Drug (STY)	5/*	-13.6	53.88	1.03	18.4	1.52	16.2	.21	2,232.1
Carter-Wallace (CAR)	6/*	-14.7	34.00	.79	21.5	.54	14.3	.11	467.1
Bristal-Myers (BMY)	7/*	-16.6	43.50	.70	14.8	1.40	18.1	.06	5,245.5
Smithkline Beck. (SKB)	8/*	-17.1	52.00	1.18	35.6	1.66	12.0	.06	4,173.5
Scherer RP (SCHC)	9/*	-17.3	13.13	.22	29.4	.36	14.4	.40	257.6
Warner-Lambert (WLA)	10/*	-17.5	69.50	1.06	16.5	1.80	17.4	.38	3,387.7

The following are the 10 companies in each of 10 industries that had the highest stock gain over the previous month (figures as of 11/5/87).

NE = Negative earnings NC = Not calculable NM = No meaningful figure * = Not among Leading 100 last month

COMPANY (SYMBOL)	RANK THIS MONTH/ LAST MONTH	PRICE INCREASE LAST MONTH (%)	CLOSING PRICE ($)	EARNINGS PER SHARE		LATEST DIVIDEND ($)	P/E RATIO	DEBT/ EQUITY RATIO	LATEST 12 MONTHS' REVENUE (IN MILLIONS)
				LAST QUARTER ($)	CHANGE FROM 1 YEAR AGO				
ELECTRONICS									
Linear (LINE)	1/*	13.3	12.75	.28	-17.6	—	14.5	.47	56.3
Telemation (TLMT)	2/*	5.0	2.50	.09	350.0	—	15.6	.44	11.4
Hytek Microsyst. (HTEK)	3/*	.0	2.75	.10	NE	—	NE	.00	19.5
Sage Labs (SLAB)	4/*	.0	13.00	.45	-35.7	.20	12.1	.51	4.5
BR Communicotions (BRHF)	5/*	-3.4	7.00	-.04	-100.0	—	NE	.00	7.8
Adams Rus. I. (AAR)	6/*	-3.9	40.3B	.05	25.0	.16	NM	2.60	47.6
Am. Precision (APR)	7/*	-6.0	13.75	.10	66.7	.20	49.1	.09	35.9
Ripley (RIPY)	B/*	-6.9	6.75	.13	.0	.20	20.5	.19	5.5
LaBarge (LB)	9/*	-8.0	1.50	-.01	NE	—	16.7	5.03	55.B
Kevlin Micro. (KVLM)	10/*	-B.3	2.75	.03	200.0	—	NM	.00	5.9
HEALTH									
Biospherics (BSPR)	1/*	4.2	6.25	.06	50.0	—	52.1	.04	9.B
Intl. Hydron (HYO)	2/*	.0	10.00	.17	30.B	—	20.8	.94	77.B
Birtcher (BIRT)	3/*	-4.0	2.B8	.04	NE	—	NE	.04	5.6
Intl. Clin. Lob. (ICLB)	4/*	-7.4	15.63	.22	57.1	—	25.2	.64	205.5
Electro Biology (EBII)	5/*	-9.5	6.00	.12	100.0	—	21.4	.01	36.4
ADAC Lobs (AOAC)	6/*	-11.7	1.B8	.02	NE	—	4.8	.54	56.6
Bord C R (BCR)	7/*	-11.8	33.75	.54	22.7	.4B	16.6	.14	618.6
Gammo Biologic (GAMA)	B/*	-12.0	5.50	-.01	NE	—	NE	.17	17.9
Dynatech (OYTC)	9/*	-13.6	22.25	.52	-10.3	—	11.4	.34	336.3
US Surgicol (USSC)	10/*	-13.7	26.75	.42	23.5	.40	1B.6	.64	238.4
METALS FABRICATION									
Elco Inds. (ELCN)	1/*	-7.3	23.63	.70	191.7	.BB	10.9	.44	130.1
Am. Locker (ALGI)	2/*	-9.6	11.75	.24	-27.3	.2B	11.0	.03	26.4
Clabir (CLG)	3/*	-13.6	4.00	-1.41	NE	.72	NE	7.36	390.7
Synalloy (SYO)	4/7	-16.4	4.50	-.07	-100.0	—	NE	.20	47.5
Intl. Aluminum (IAL)	5/*	-17.3	16.75	.40	42.9	.B0	10.6	.13	170.4
Wymon-Gordon (WYMN)	6/*	-19.6	14.BB	.14	16.7	.B0	NE	.07	324.3
Coml. Metols (CMC)	7/*	-21.3	16.13	.29	-31.0	.32	14.1	.26	872.8
Pitt OesMoines (POM)	8/*	-21.9	18.75	-.72	NE	—	NE	.32	257.4
Zero (ZRO)	9/*	-22.4	14.75	.24	14.3	.36	15.4	.12	127.1
Groff Ind. (GROF)	10/*	-22.9	9.25	.46	1B7.5	.05	9.6	.00	34.3
SCIENTIFIC AND ELECTRONIC INSTRUMENTS									
Oetector Elctr. (DETX)	1/*	39.1	B.00	.02	NE	—	NE	.25	16.6
Sippicon (SOSI)	2/*	7.9	17.00	.21	-16.0	—	19.B	.03	55.7
Boird (BATM)	3/*	1.1	22.25	.20	25.0	—	30.1	.43	55.9
Monitor Tech. (MLAB)	4/*	-4.B	2.3B	.12	NE	—	9.5	.25	9.0
Mangood (MAB)	5/*	-7.0	6.63	.38	-92.1	—	NE	7.24	76.5
Buehler Intl. (BULR)	6/*	-8.9	B.BB	.1B	100.0	.12	20.6	.06	63.7
Opticol Coatg. Lab. (OCLI)	7/*	-11.B	14.BB	-.05	-100.0	—	57.2	.05	69.0
Astrosystems (ASTR)	B/*	-11.9	6.50	.06	-62.5	—	16.3	.00	13.2
Rheometrics NC (RHEM)	9/*	-12.0	5.50	.27	80.0	—	NE	.28	19.5
FBX (FBXC)	10/10	-12.1	3.63	-.03	-100.0	—	90.6	.17	13.4
SOFTWARE AND DATA PROCESSING									
Henry Jock Assoc. (JKHY)	1/*	15.4	3.75	.04	-63.6	—	23.4	.1B	16.0
Penta Sys. Intl. (PSLI)	2/*	7.4	1.BB	-.31	-100.0	—	NE	.13	19.9
Dicomed (DCOM)	3/*	5.6	2.25	-.11	NE	—	NE	.3B	20.3
Comp. Data Syst. (CPTO)	4/*	-5.5	B.63	.30	150.0	.10	10.9	.73	57.3
Oyotron (OYTR)	5/1	-6.0	11.75	.2B	366.7	—	12.1	.12	36.2
Wiland Services (WSVS)	6/*	-6.9	1.75	.03	-50.0	—	NE	1.35	14.3
BGS Systs. (BGSS)	7/*	-9.5	5.BB	.05	-37.5	—	NE	.01	12.6
Comp. Language (CLRI)	8/*	-9.9	5.75	-.22	NE	.12	NE	.08	94.7
Lodgistix (LOGX)	9/*	-10.B	2.06	-.13	-100.0	—	NE	.02	19.B
Algorex (ALGO)	10/*	-11.1	2.56	-.10	NE	—	NE	.5B	7.6

SOURCE: MEDIA GENERAL FINANCIAL SERVICES

AIDS Crisis Spurs Hunt For New Tests

A variety of advanced technologies offer new ways to detect and monitor the deadly disease

BY VICKI GLASER

AS THE AIDS epidemic spreads, the rush to test anyone and everyone for the killer virus is picking up steam. Blood banks screen all the blood they collect. Several U.S. government agencies, including the armed forces, the State Department foreign service, the Labor Department's Job Corps program, and the Peace Corps, check all applicants.

President Reagan has asked for mandatory testing of prisoners and immigrants, and 35 states have introduced bills calling for premarital AIDS testing. Many private companies want to test their employees, as do insurance companies with applicants for life and health insurance. Businesses devoted solely to AIDS screening, including "AIDS-free" dating clubs, have sprung up across the country.

The testing fever is understandable. The more than 42,000 cases of acquired immune-deficiency syndrome diagnosed in the United States are only the beginning. An estimated 1.5 million more Americans carry the AIDS virus, and nobody knows who they are. AIDS cures, treatments, and vaccines are critical priorities, but so far researchers have made little progress. In the meantime, the immediate concern is to identify contaminated blood products and find out who has the disease before it infects more people.

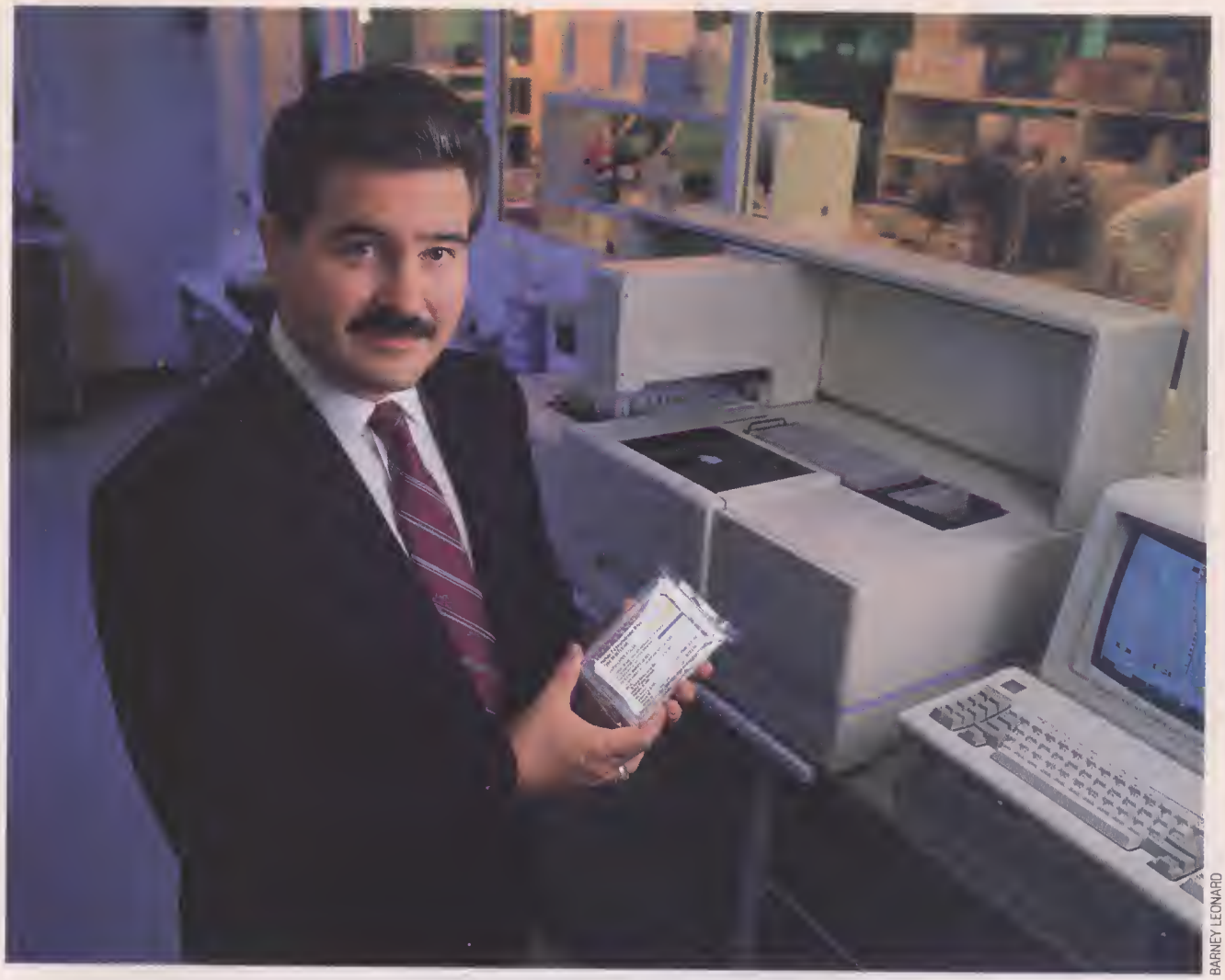
The need to know has created an AIDS-testing market estimated at $100 million annually, most of which comes from the mass screening of blood. As the calls for testing intensify over the next five years, that figure is expected to double.

And as more cases are detected, industry watchers also foresee growth in the relatively small AIDS-diagnostics market, which gives doctors tools to determine the progress of a patient's infection, the virus' activities, and its response to treatment.

Although two large pharmaceutical companies—Abbott Laboratories and Du Pont—dominate the testing market, many smaller biotechnology companies produce some of the most innovative research into new kinds of tests. But because the established tests work reasonably well, the pioneering companies must demonstrate that their products work significantly better than existing products do, or that they address markets and applications the leaders ignore. Therefore, some of the new entrants may choose to bypass the blood-screening market, which is already saturated, to work on the more complex tests that can be used to help diagnose and treat the disease.

The smaller companies searching for new tests must also contend with the enormous financial strength of the market leaders. To obtain solid financial backing, many small companies are relying on partnerships with established firms to acquire the necessary staying power and market muscle.

Still, the new entrants may find a niche. The Abbott and Du Pont tests in general use search for indirect evidence of the presence of the AIDS virus. These relatively cheap and accurate tests, called ELISAs (enzyme-linked immunosorbent assays), look for AIDS antibodies, the substances the body produces to fight the AIDS virus. But antibodies in-



BARNEY LEONARD

Du Pont's Fred Fraser demonstrates the company's automated AIDS-testing equipment.

dicate only that the individual was exposed to the AIDS virus, not whether he or she has actually been infected. In addition, ELISA tests often give false positive readings and require expensive backup tests, called Western blots.

Several companies are working on new technologies for backup tests, such as glow-in-the-dark immunofluorescence assays.

Other companies are developing different approaches to today's ELISA tests, designed to reduce the number of false positive results. For example, recombinant-DNA tests use synthetic viral material that is not contaminated with cellular debris as the natural virus used in traditional tests sometimes is.

Perhaps the worst failing of all these "indirect" antibody tests is that they cannot detect the disease during the months-long "window" between when the body becomes infected and when it begins to produce the telltale antibodies. A new crop of direct tests seeks to close that window. Antigen tests, for example, look for molecules the virus creates on the surface of infected cells; other tests probe for the DNA or RNA that make up the virus itself.

Exactly when the new tests will hit the market is an open question. Some companies have submitted their tests to the Food and Drug Administration for approval, but the FDA is not pushing as hard to approve the new tests as it did to approve the screening tests that protect the nation's blood supply. Fred Fraser, business manager of blood processing for Du Pont, says the FDA often tries to fight monopolies by licensing two or more similar products almost simultaneously. Neither the FDA nor the companies involved will speculate on when or if the agency will approve any specific product, but some observers estimate an average of 18 months from submission to approval. The need for diagnostic tests remains small until more drugs become available for treating AIDS once a patient is diagnosed.

In the meantime, the primary market will remain the antibody-based screening tests. Abbott, which does its own research and development, manufacturing, and marketing, received FDA approval for its ELISA test almost three years ago. It was the first company to do so, and it has become the clear leader in the worldwide market for AIDS screening; the company now controls more than half the U.S. testing market.

"It seems as if Abbott will dominate the market for the next few years,"

THE AIDS TESTS

ELISA. The ELISA (enzyme-linked immunosorbent assay) is the most widely used test for detecting antibodies to HIV (human immunodeficiency virus—the AIDS virus) in blood. Improvements over the initial ELISAs, which were first approved in 1985, have increased the test's sensitivity and specificity. Today's ELISA tests are safe and simple, and at $1.50 each, they are relatively inexpensive compared to the more sophisticated tests now under development. These features make the ELISA attractive for high-volume screening operations.

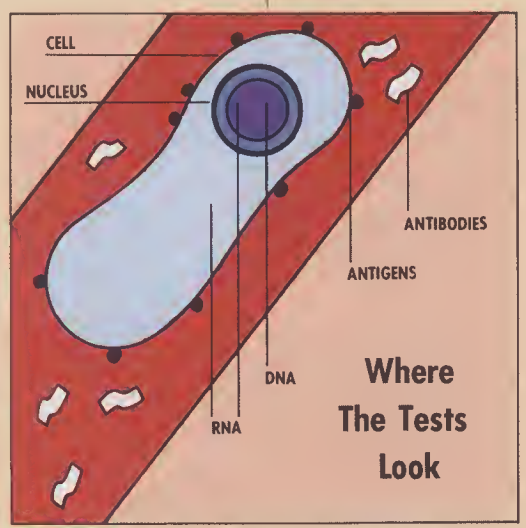
The test involves mixing viral material (isolated from an infected person and treated to be harmless) with a patient's blood and a chemical "label." HIV antibodies present in the sample bind to the viral antigen, triggering a reaction that produces a color change to signal a positive test. An ELISA tests only for exposure to the virus, not infection, and antibodies may not appear for months after exposure. Automated versions run on computer-driven equipment.

Western blot. This procedure is more sensitive than the ELISA, but also more costly and time consuming. Laboratories use the Western blot to confirm the presence of HIV antibodies in samples that repeatedly test positive on ELISAs.

The Western blot uses the same viral isolate as the ELISA does to detect HIV antibodies, but an electric charge separates the viral proteins on a membrane before adding a patient's blood sample. This permits more accurate identification of specific HIV antibodies in the patient's blood than can be achieved with the ELISA. The FDA has approved the first Western blot tests.

Immunofluorescence assay. This test is also used to confirm positive ELISA tests, staining the sample's blood cells so that the presence of HIV antibodies will produce a fluorescent reaction. Faster than the Western blot and currently available in Europe, immunofluorescence assays are not easily automated and require a fluorescence microscope. The test is in the FDA approval process.

Recombinant DNA. Instead of using HIV proteins isolated from infected individuals, this test uses genetically engineered DNA to create synthetic proteins specific to the AIDS virus. When mixed with a patient's blood, the synthetic antigens bind to HIV antibodies, producing a color reaction. Using these highly specific, purified proteins should reduce false positives by eliminating contamination of the sample by other viral particles. Recombinant DNA tests are now undergoing clinical trials.



Today's tests search for AIDS antibodies floating in the blood. New tests will check cells for viral antigens, DNA, and RNA.

KAREN KARLSSON

Rapid latex agglutination. This technique uses small latex beads coated with recombinant antigens. The tester mixes the blood with the beads, and clumping—agglutination—signals a positive test. This simple test needs no special equipment, making it convenient for use in a doctor's office or in the field. But packaging the test is expensive, and the test will probably cost more than ELISA tests. This test is now in clinical trials, and could be on the market this year.

Antigen tests. All of the tests described above are indirect—they look for evidence of the body's attempt to fight the virus, not the virus itself or its direct products. The antigen test, on the other hand, looks for HIV antigens, proteins produced by the virus on the surface of infected cells. Developers of antigen tests hope that different antigen levels indicate different stages of the disease, making the test useful in monitoring drug therapy.

The test detects viral antigens using a monoclonal antibody, a compound that recognizes and binds only to the target proteins. Binding of the monoclonal antibody with an HIV antigen provides direct evidence of infection. Antigen tests can detect infection long before the antibodies show up, but when the antibodies do appear they tend to mask the antigens. The FDA is reviewing several antigen tests.

DNA probe. This direct test mixes a probe composed of a section of viral DNA labeled with a radioactive or chemical tag with cells from a patient's blood. The labeled probe links up with any similar viral DNA found in the blood, signaling the presence of HIV. The problem with DNA probes has been to find enough viral DNA, even in infected cells, to create a positive result. This test can certify that a patient has been exposed and infected and that the virus is present in blood cells. DNA probe boosters hope to show that some individuals exposed to the virus no longer have it in their blood cells, a discovery that could influence AIDS therapy. DNA probes are not yet in clinical trials.

RNA probe. Similar in theory to the DNA probe, the RNA probe looks for messenger RNA (mRNA), which contains instructions, transcribed from the DNA, for reproducing the virus. Only active viruses create the short-lived mRNA, so a positive result shows that the virus is active as well as present. Because viral DNA can produce as many as 10,000 mRNA copies, RNA probes also circumvent the DNA probe's amplification problem. RNA probes have not yet begun clinical trials.

says biotech analyst Robert Kupor at Cable, Howse & Ragen. Abbott's tremendous strength in the AIDS market rests on its experience and history in pharmaceuticals, according to Kupor; its momentum will give the company time to match any new technology from smaller competitors. Says Kupor, "Abbott can hang in there for six to nine months until it can match any superior test that comes on the market."

Abbott has already demonstrated its staying power. The American Red Cross, which collects more than half the nation's 13.2 million units of blood each year, has contracted to use Abbott's ELISA test exclusively for two years. The Red Cross defends its decision to go with Abbott, but a study sponsored by the National Institutes of Health in 1986 found that competitive tests from Du Pont and Genetic Systems—which then shared some of the Red Cross market—were better than those from Abbott or Electro-Nucleonics, then the second-ranked ELISA supplier. The new tests recorded fewer false positive results, but Abbott held on until it could match the new competitors by licensing an improved test last January.

"In the beginning, the speed of getting a product out was of main importance," explains Richard H. Decker, Abbott's manager of experimental biology research. Decker adds that Abbott "will continue to try improving the processes we have developed. Abbott has a lot of expertise in virology and molecular biology."

After improvements in all the tests during the past year, most observers now consider all FDA-licensed ELISA products to be comparable in quality and effectiveness.

While Abbott has weathered its troubles, Electro-Nucleonics, which received approval for its AIDS test just a week after Abbott, has seen competition force its market share down from the almost 40 percent it garnered immediately after introducing the product. The company still claims to provide almost 30 percent of the AIDS test units used in the United States, but some observers give the company only a 10 to 15 percent market share.

Unlike Abbott, Electro-Nucleonics lacked the marketing punch to hold on until its tests matched the competition, and lost market share to new competitors such as Cetus, Bionetics Research, and a joint venture between Du Pont and Biotech Research Laboratories.

The Du Pont venture, despite little experience in the field, claims to have snagged almost a quarter of the blood bank and commercial reference laboratory AIDS-screening market. Du Pont's Fraser says the company's success is the result of marketing. "Yes, our product is good, but so are the other products on the market," he acknowledges. "We can offer service, backup, and support." Du Pont has grabbed lucrative contracts with the Army, the Air Force, and the New York Blood Bank. The company even promotes its test with a major television advertising campaign.

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Although Abbott and Du Pont dominate the testing market, many smaller companies produce some of the most innovative research into new kinds of tests.

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The Du Pont/Biotech Research combination also dominates the market for confirmatory Western blot tests, worth an estimated $20 million per year. The company is the only one with FDA approval, though Abbott and Cetus have also requested FDA approval for their versions. Epitope has signed a $3-million agreement to supply Holland's Organon Teknika with its Western blot test for marketing in Western Europe and elsewhere.

Du Pont's Fraser admits that the new Western blot tests use the same technology as his company's, and predicts they will grab market share when they are approved.

Meanwhile, Electro-Nucleonics hopes to bounce back with its immunofluorescence test, now under consideration at the FDA. Like a Western blot, the test confirms the presence of AIDS antibodies detected by an ELISA test. Though it is said to be faster, it also is labor-intensive, and is unlikely to replace the Western blot. Du Pont, among others, is working to extend the life of the Western blot by automating the process and cutting costs.

Researchers at several companies, including Abbott, Electro-Nucleonics, Cambridge BioScience, and Chiron (in conjunction with Johnson & Johnson), are working on tests that would compete with existing ELISA technology. Using recombinant DNA, these tests replace the actual virus used in older tests with synthetic, purer viral material that early results suggest would be less likely to react to antibodies from other viruses. These tests promise to be less expensive and easier to use than current ELISA tests, according to James McCamant, editor of the *Medical Technology Stock Letter;* he predicts the new techniques could reduce the need for costly confirmatory tests and take over the screening market.

Cambridge BioScience, incorporated in 1981 to develop diagnostic tests and vaccines for a variety of infectious diseases, was preparing to complete clinical trials and send its Recombigen test to the FDA for approval late last year. The company says it hopes the FDA will approve the test this year.

As soon as that happens, Cambridge BioScience plans to send the test to market in two formats. The first is an ELISA-style test that takes about two hours and is easily automated for high-volume operations. The second is a more expensive but faster rapid-latex-agglutination, or clumping, test that requires little equipment and can be performed in a physician's office or in the field. Late last year, Cambridge BioScience sold exclusive worldwide marketing rights for the new test to Baxter Health Care Corp., based in Chicago. Cambridge BioScience hopes this agreement will give it the marketing muscle to compete with the industry's billion-dollar giants.

Abbott, the other leading competitor for recombinant-DNA tests, hopes to go a step further by marking stages of disease activity. Studies suggest that different proteins may be associated with different stages of the disease, according to the company, and Envacor, Abbott's recombinant-DNA product, can distinguish among AIDS proteins. Decker says that recombinant-DNA tests will increase both sensitivity and specificity. "Recombinant antigens

[DNA] give you a little more flexibility in looking for specific antibodies" and help detect infection earlier than did previous tests.

Decker adds that recombinant-DNA tests will play a special role once an AIDS vaccine is developed. Vaccinated individuals will show up as infected on current tests, Decker says, but recombinant-DNA tests may be able to tell the difference.

Abbott submitted Envacor to the FDA nearly two years ago, and plans to market it as both a diagnostic and mass-screening test.

Despite the enthusiasm of companies working on recombinant-DNA tests, critics warn that synthesizing the viral material could actually make the test less sensitive. Unlike tests that use portions of the actual virus, recombinant-DNA tests might not recognize all the different forms of AIDS antibodies and could give false negative results.

The most sophisticated AIDS tests under development take an entirely different tack. Instead of testing for disease-fighting antibodies as do the ELISA, Western blot, immunofluorescence assay, and recombinant-DNA tests, they look for the virus itself or the antigens it produces. Presently too costly and labor-intensive for mass screening, direct tests may find their first use with patients who are known to have the disease.

Although antigen tests are considered direct tests, they search for molecules that the AIDS virus makes on the surface of infected cells; these antigens prompt the body to create the antibodies identified by indirect tests. Besides indicating infection rather than mere exposure, antigens also appear in the blood about two weeks after the initial infection; by testing for them, doctors can spot the disease faster. Antigen tests would also let doctors detect the transmission of the AIDS virus to newborn children. (Indirect tests are not sufficient in this case, because antibodies present in the infant's blood could have been passed on from the mother.)

As with the other tests, Abbott, Du Pont, Electro-Nucleonics, and Epitope lead the way in the search for antigen tests. In May, Abbott became the first to submit its version to the FDA; it hopes to evaluate the progress of AIDS treatments by using the test to monitor antigen levels.

However, Du Pont has a marketing advantage. Its antigen test kit, which the company was preparing to send to the FDA late last year, uses the same hardware and software as its ELISA antibody tests, which would make it easier and cheaper to use for its base of ELISA customers. But Du Pont's Fraser warns that the FDA is not likely to approve antigen tests for several years.

Electro-Nucleonics, which was formed in 1960 and is far smaller than either of its two competitors, plans to send its antigen test to the FDA early this year. The company funded its development with a $7.8-million research-and-development partnership with Prudential-Bache. Electro-Nucleonics has also agreed to work with Swedish drug giant Pharmacia AB on future AIDS tests, even though Pharmacia is devel-

WHO MAKES AIDS TESTS

COMPANY	1986 SALES AND R&D REVENUE	TECHNOLOGY
Abbott Laboratories Abbott Park, IL 60064 (312) 937-6100	$3.8 billion	Approved ELISA test; submitted Western blot test and antigen test to FDA; working on recombinant-DNA test; with Amgen, working on DNA probe test
Bionetics Research 5516 Nicholson Lane Kensington, MD 20895 (301) 881-5600	Not available	Approved ELISA test
Biotech Research Laboratories 1600 E. Gude Dr. Rockville, MD 20850 (301) 251-0800	$6.2 million	With partner Du Pont, approved ELISA and Western blot tests; working on antigen test
Cambridge BioScience Biotechnology Research Park 365 Plantation St. Worcester, MA 01605 (617) 797-5777	$840,000; also more than $1 million in interest revenue	Working on recombinant-DNA test, sold marketing rights to Baxter Health Care Corp.
Cetus 1400 53rd St. Emeryville, CA 94608 (415) 420-3300	$40 million (fiscal year ended June 1987)	With partner Kodak, approved ELISA test; submitted Western blot test to FDA; working on DNA probe
Chiron 4560 Horton St. Emeryville, CA 94608 (415) 655-8730	$9.4 million	Working on recombinant-DNA test

COMPANY	1986 SALES AND R&D REVENUE	TECHNOLOGY
Du Pont 1007 Market St. Wilmington, DE 19898 (302) 772-5500	$27 billion	With partner Biotech Research, approved ELISA and Western blot tests; working on antigen test
Electro-Nucleonics Box 2803 Fairfield, NJ 07007 (201) 227-6700	$63 million	Approved ELISA test; submitted immunofluorescence test to FDA; working on recombinant-DNA and antigen tests
Enzo BioChem 325 Hudson St. New York, NY 10013 (212) 741-3838	$7.3 million	Working on DNA probe
Epitope 15425 S.W. Koll Parkway Beaverton, OR 97006 (503) 641-6115	$1.1 million	Working on antigen test
Genetic Systems 3005 First Ave. Seattle, WA 98121 (206) 728-4900	Not available	Approved ELISA test
Gene-Trak Systems c/o Integrated Genetics 31 New York Ave. Framingham, MA 01701 (617) 875-1336	$8.5 million	A joint venture of Integrated Genetics and Amoco; working on RNA probe

oping its own tests for the international market.

Epitope, a tiny biotech company working under contract with SYVA, the diagnostics division of Syntex, is counting on a rapid two-hour turnaround time to make its antigen test a success. The company also plans to simplify the automated system into a test kit that can be used in a doctor's office. Epitope hopes to submit the first phase of its test to the FDA this spring.

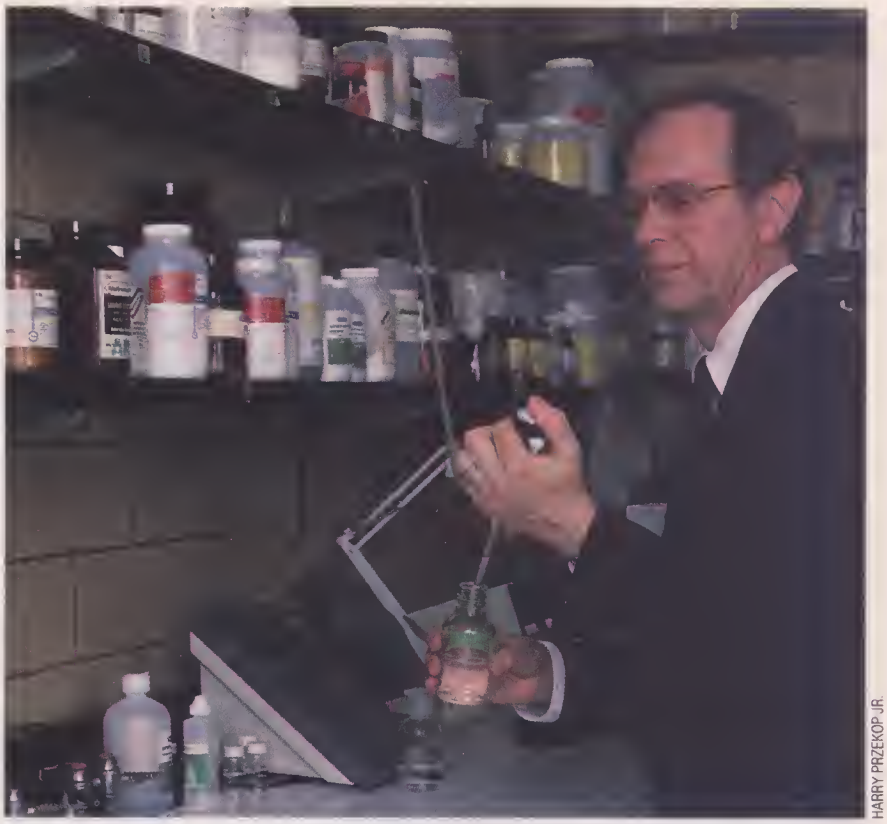
Despite that optimism, so far only the companies that make antigen tests are excited about them. And although Decker thinks antigen tests will find a place, he says they probably won't mean dramatic improvement in blood screening. All are wrestling with the tendency of antibodies to mask AIDS antigens. On a more basic level, critics argue that discovering antigens in the bloodstream doesn't tell researchers anything they didn't already know.

Some observers hold out hope for direct tests that look for the virus itself. By identifying the virus' genetic material in the cell, these tests could provide more information about the level of infection. Two kinds of direct tests are under development: DNA probes that look for the virus in the cell's nucleus, and RNA probes that search for a short-lived form of the active virus throughout the infected cell. These tests have yet to prove their practicality, however.

Cetus/Kodak leads the pack working to develop a DNA probe, according to Stuart Weisbrod, a research analyst at Prudential-Bache Securities. Cetus and Kodak share the research-and-development efforts and funding, but Kodak will manufacture and market the test. Cetus/Kodak's advantage centers around its ability to make the viral DNA in infected cells replicate itself as much as a million times, which makes the DNA much easier to detect. Because DNA probes detect the virus immediately after infection, Cetus/Kodak thinks they eventually will be used in the mass-screening market, and hopes to automate the test early this year.

Others working on DNA probes include Enzo Biochem, which uses a powerful radioactive label to amplify the DNA signal, and a collaboration between Abbott and Amgen Inc. of Thousand Oaks, Calif.

Gene-Trak Systems, a joint venture of Integrated Genetics and Amoco, avoids the DNA-amplification issue by searching for viral RNA instead. Each infected cell synthesizes as many as 10,000 copies of messenger RNA, making it far easier to detect. The RNA probe has an additional advantage as well. "Messenger RNA is a very short-lived molecule. If you can detect it, you know you are seeing a recently made, virus-specific product," explains Jim Richards, director of business planning and development at Integrated Genetics. A positive result on an RNA probe indicates that the virus is not only present, but active.



HARRY PRZEKOP JR.

Abbott's Richard Decker expects a special role for DNA tests once an AIDS vaccine is developed.

The RNA probe's potential depends on what kinds of AIDS therapies are developed. The RNA probe measures short-term virus activity, and if that turns out to be important in evaluating new AIDS drugs, the RNA probe could be well positioned. Gene-Trak claims the test has already helped monitor AZT, the only approved AIDS treatment.

The search for better tests goes on, but the AIDS screening tests already available have proven safe, effective, and reliable within their limitations. The Red Cross reports just six confirmed cases of AIDS contracted from the nine million transfusions since testing began in March 1985.

However, there clearly is room for tests that do a better job. As the AIDS epidemic spreads, the need for diagnostic tests will mushroom. Work on cures, treatments, and vaccines also rely on accurate tests to monitor results. New field-based tests are already finding a place in developing countries, where the need is great, the technology limited, and the FDA's authority weak.

The AIDS virus is incredibly complex. Each of the test makers is convinced that its test will unlock important secrets about the virus.

The key to commercial success lies in being first to market new test technology and package it in cheaper, efficient formats for specific uses. With the stakes so high—in lives as well as dollars—no one can afford to ignore any avenue that offers hope in coping with the deadly disease. ■

Vicki Glaser is a free-lance science and medical writer.

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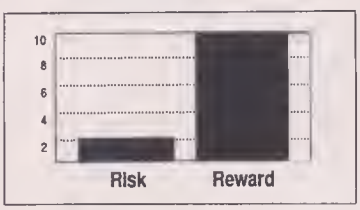

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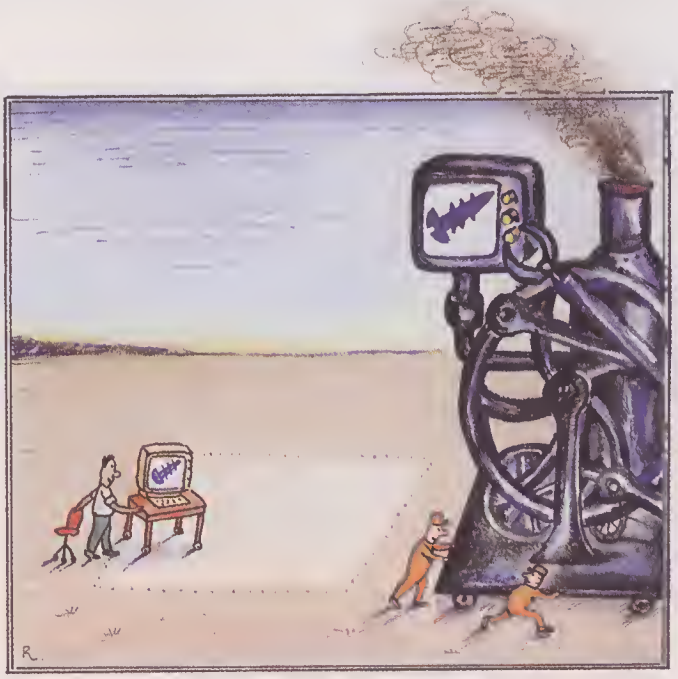
CAD/CAM's $800 Million Winners

Falling profits and new demands from big customers push computer-aided-design suppliers to standardize

BY G. BERTON LATAMORE



MARC ROSENTHAL

AT GENERAL Motors, the world's largest manufacturer, engineers are ensconced in design offices all over the world. Like engineers in many other large companies, GM staffers are in the habit of buying hardware and software for computer-aided design. So far, so good; computer-aided design (CAD), which automates drafting and calculations that used to be done by head and hand, has proven to be a tremendous boost for engineering productivity.

The problem, however, is that separate divisions have purchased CAD systems without giving a thought to how they would fit into a larger, corporate computer network. GM wants to link its operations more closely, but many of its design systems can't share data.

The company's solution is a massive new CAD purchasing program that pits suppliers against a rigorous set of specifications. The guidelines weed out all but two CAD companies, which will work with GM for the next three years to develop a standardized system that can be used interchangeably throughout the company. In return for their development, the two winners—Cadam and McDonnell Douglas—will get most and possibly all of the automaker's potential $800 million in CAD expenditures during the course of the program.

The GM project typifies emerging new rules for the $4.3-billion annual CAD market. Major buyers such as Boeing, GM, and the armed services are taking CAD purchasing power away from their engineers and giving it to high-level planners who are redefining CAD needs on a company-wide rather than a departmental basis. The result is a shift in power from CAD suppliers to users, who are demanding standardized programs that communicate readily.

This market shift may prove devastating for the large computer-aided design and manufacturing (CAD/CAM) companies that have grown up with proprietary hardware and software systems designed to stand alone. A prime example is CAD/CAM industry

GM'S WINNERS

John Mazzola, executive vice president.

McDONNELL DOUGLAS

FOUNDED 1978

1986 REVENUES $100 million to $150 million

PRODUCT HIGHLIGHTS Software runs on and is sold separately from standard industry hardware. Designed to ease communication of engineering data to manufacturing equipment, and to integrate with other software.

FUTURE PROSPECTS Before its selection by GM, McDonnell Douglas was considered the weakest of the large suppliers; many analysts speculated that its CAD operation was losing money. However, the GM deal gives the company the strong footing it needed in the auto industry. What's more, the new McDonnell Douglas technical innovations—software for linking computer-aided design data directly to quality-control equipment—may prove a significant boost to the company, according to David Burdick, Dataquest's top CAD/CAM analyst.

ADDRESS 325 McDonnell Blvd.
Hazelwood, MO 63042
(314) 232-3890

Frank Puhl, president.

CADAM

FOUNDED 1982

1986 REVENUES $150 million (includes IBM hardware to run Cadam software)

PRODUCT HIGHLIGHTS Software known for rapid response and for being easy to learn; supports more terminals than competing software and is compatible with an IBM database system for storing CAD files.

FUTURE PROSPECTS Generally considered a solid company; major customers include Boeing Aerospace and IBM. However, analysts say that Cadam fears it will be supplanted by Catia as IBM's primary CAD/CAE software supplier, and is building an independent sales force to tap markets not serviced by IBM. This effort is off to a running start with Cadam's selection by GM. In addition to sales to the auto company, says David Owens, Cadam director of marketing and business planning, the deal should pull in a lot of new business from GM's many suppliers.

ADDRESS 1935 N. Buena Vista St.
Burbank, CA 91504
(818) 841-9470

SOURCE: MACHOVER ASSOCIATES/HIGH TECHNOLOGY BUSINESS RESEARCH

leader IBM, whose more than $1 billion in sales last year accounted for a quarter of the total market, according to industry analysts Daratech. IBM markets CAD/CAM software licensed from four different companies to boost hardware sales. Other large-system suppliers, according to Daratech, are Intergraph, with about 15 percent market share; Computervision, with 12.3 percent; Calma, a General Electric company in Milpitas, Calif., at 5.1 percent; Mentor Graphics in Beaverton, Ore., at 4.3 percent; Applicon, a unit of Schlumberger in Ann Arbor, Mich., at 4 percent; and McDonnell Douglas, at 3.8 percent of the market.

Called turnkey systems because they are sold complete and ready to use, these large-scale hardware/software combinations have formed the backbone of the CAD/CAM market. Now, however, many of the turnkey companies are beginning to feel a squeeze. IBM, for instance, will see its growth rate plummet to an estimated 8 percent in 1987, compared to 1985 CAD/CAM sales that grew by more than 50 percent, estimates Daratech. Similarly Intergraph, rated second in CAD/CAM sales, was expected to grow at only a 10 percent rate in 1987; two years ago it was bounding ahead at about 60 percent. Daratech expects third-place player Computervision to record no growth for 1987. For the market as a whole, the most pessimistic experts predict no growth at all this year, while the most optimistic projections run at about 20 percent growth—a major drop from the 50 percent annual growth rates of three years ago.

This doesn't mean that CAD/CAM is a declining or even a maturing market. About 90 percent of America's engi-

THE RUNNERS-UP

James Medloc, president.

INTERGRAPH

FOUNDED 1969

1986 REVENUES $606 millian

PRODUCT HIGHLIGHTS Emphasizes the integration of CAD systems using its proprietary data format.

FUTURE PROSPECTS Generally a strong company despite the recent lass af Boeing Commercial Airplane's CAD business. However, it provides proprietary hardware/software systems that da nat integrate well with other CAD systems, and probably will have ta make majar adjustments as its market begins ta demand nonproprietary saftware.

ADDRESS 1 Madisan Industrial Pork
Huntsville, AL 35807
(205) 772-2000

Joseph Guglielmi, division president.

CATIA/IBM

FOUNDED 19B2

1986 REVENUES Not ovoilable; sales of Catia saftware account far part af IBM's estimated $1-billian annual CAD take

PRODUCT HIGHLIGHTS Nated far powerful 3-D surface and salids madeling; has many built-in links for communicating engineering data ta factary equipment.

FUTURE PROSPECTS Baeing Cammercial Airplane recently dumped Intergroph, making Catia/IBM its sole supplier af CAD equipment. IBM remains the only U.S. distributar for Catia, which appears to be the main CAD system it sells.

ADDRESS 472 Wheelers Farms Rd.
Milford, CT 06460
(203) 783-7010

Robert Gable, president and CEO.

COMPUTERVISION

FOUNDED 1969

1986 REVENUES $495 million

PRODUCT HIGHLIGHTS CAD modules designed for specific uses, such as designing mechanical parts. Modules may be tied tagether by plugging them inta a central core processor.

FUTURE PROSPECTS One af the strongest campanies in CAD, second anly to IBM in sales. The U.S. Navy has been ane of its largest custamers, but it daes nat necessarily have an edge in bidding for the current $2-billion round af Novy cantracts.

ADDRESS 100 Crosby Dr.
Bedford, MA 01730
(617) 275-1800

neers and designers don't even have CAD equipment yet, so the potential purchases are staggering. It does mean that the market is shifting away from major suppliers locked into large sales forces and outmoded minicomputer-based systems.

The rising stars of CAD/CAM are less expensive programs designed to run on personal computers. The trend is being driven by the wide-scale availability of relatively low-cost, standardized workstations or 32-bit personal computers capable of processing the graphic images generated by CAD software. Manufacturers increasingly can buy CAD software separately from hardware and move the software from one supplier's workstation to another.

So far the biggest threat to the established CAD/CAM giants comes mainly from three small software sellers: Autodesk of Sausalito, Calif.; Versacad of Huntington Beach, Calif. (recently bought by Prime Computer of Natick, Mass.); and Cadkey of Vernon, Conn. Market analysts are reluctant to say exactly how much of the market is going to these and other small suppliers of CAD systems, but most agree that they are a significant threat to the giants.

"The new personal-computer-based systems are priced so much less than the high-end systems," says Daratech's Charles Jenkins. "There are a lot of low-end systems out there. For instance, IBM has less than 20,000 workstations running. By contrast, there are more than 100,000 copies of Autocad used today." Autocad, a CAD software package sold by Autokey, costs about $3,000 per copy; three years ago, a minicomputer-based CAD/CAM system from one of the turnkey suppliers ran about $100,000 per station.

Of course, established CAD companies aren't watching passively as markets erode. Many are getting into the market for off-the-shelf software. That explains Prime's recent purchase of Versacad. Similarly, Computervision is building a low-end CAD business with its personal-computer-based system.

The problem with this approach is that large companies are geared for selling pricey turnkey systems, where markups on hardware boost profit margins considerably. Profit margins on standard software are a lot slimmer and can't support the large and expen-

4 MAJOR BUYERS SET STANDARDS

BUYER	BUDGET	DETAILS	STATUS
Boeing Commercial Airplane	Not available	Boeing announced last year that it would standardize with IBM hardware and Catia software; it formerly bought only Intergraph equipment.	Boeing is making initial purchases, but the program may be slowed by Boeing's delay of its new 7J7 airliner.
General Motors	$800 million	The GM subsidiary Electronic Data Systems (EDS) issued a set of CAD specifications that were met by five companies: Cadam, Catia, Computervision, Intergraph, and McDonnell Douglas. EDS chose Cadam and McDonnell Douglas; they will get most of GM's $800 million in upcoming business.	Announcement of winners expected by January 1988.
U.S. Army Corps of Engineers	$100 million	Like GM and the Air Force, the Corps is looking for software that handles data in specific ways and can run on many different workstations.	Reviewing bids.
U.S. Navy	$1 billion to $2 billion	This largest contract in CAD history is expected to be filled by several suppliers. The Navy will pick companies that meet specific operational requirements.	Accepting and reviewing bids.

SOURCE: HIGH TECHNOLOGY BUSINESS RESEARCH

sive sales forces to which such companies are accustomed. Therefore market analysts expect to see reductions in sales staffs at a number of companies.

But even with such cuts, some turnkey suppliers may find a software-only strategy hard to support. McDonnell Douglas' CAD/CAM subsidiary, for example, was set up to sell software originally developed for company use. Daratech estimates the division's revenues have dropped from $171 million in 1985 to $162 million in 1987, and analysts attribute the decline to lost revenue from hardware sales. The company will not discuss the operation's financial performance; however, many industry watchers speculate that its future hinges on General Motors.

"McDonnell Douglas has for some time been trying to establish itself with very large users," says Joel Orr, chairman of analysts Orr Associates. "It is very important for McDonnell Douglas to make it into the auto market."

For the companies that adapt to the changing market, the payoff will be handsome. Even at GM, which for 20 years has been a pioneer in the use of computer-aided design, only 2 percent of design engineers currently use CAD systems.

GM's drive for design-system standardization is already underway. About two years ago the company set hardware standards for graphics-workstation purchases. So far, it has approved Apollo, Sun, and Hewlett-Packard systems, says Raymond Kahn, coordinator of the program. IBM and Digital Equipment are trying to get certification.

Next, GM advertised for CAD/CAM partners to help develop $800 million worth of standardized software exclusively for GM's use. But there was a catch: Candidates would have to first demonstrate that they could deliver software that performed according to a rigorous set of specifications.

Five companies met the challenge: IBM with its Catia software, Cadam, Computervision, Intergraph, and McDonnell Douglas. Cadam and McDonnell Douglas got the nod in November. After the three-year development program, says Kahn, GM expects to open its CAD/CAM purchases to other suppliers who can conform to the standards. However, the company still wants to cut the number of suppliers; the computerized Tower of Babel created by buying from about 20 different companies has made data transfer impossible. "We have been a victim of the technology," laments Kahn.

The Army and Navy are rallying around a set of CAD/CAM standards published by the Department of Defense in 1986. Although the armed forces do not manufacture equipment, they do a great deal of preliminary design for new weapons systems, and they keep final design copies of airplanes, tanks, ships, and other equipment. That makes the military a major CAD customer; the Navy alone is currently looking at as much as $2 billion in bids, the largest such CAD/CAM purchase ever.

Some critics point to problems in companies' drive for standardization. They say internal standards do nothing to promote an industrial CAD/CAM format that could be applied universally.

In addition, large, fragmented companies often have difficulty getting all divisions to back a limited group of suppliers. At GM, for instance, operating units have never agreed on a standard way to design cars on paper, much less by computer.

GM spokesman Mark Cocroft dismisses such skepticism. "If a division wants to buy from its own CAD/CAM supplier but the corporation says it has to buy from someone else, the division will buy from someone else," he says.

Whether GM's program succeeds or not, it clearly points the way for the future of the CAD/CAM business. Low-cost, interchangeable software packages—designed for generic workstations or personal computers—will continue to supplant large, dedicated hardware/software systems.

Of course, if GM's program succeeds, it will mean handsome contracts and the assurance of future business for its suppliers. Says analyst Orr, "I think winning GM's nod would be important for any company." ■

G. Berton Latamore writes on technology for a number of national publications.

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DEC President Kenneth Olsen

ON COMPUTER NEEDS IN THE 1990s

THE COMPUTER INDUSTRY is still young enough to be dominated by some of its earliest pioneers. One of them is Kenneth H. Olsen, president and founder of Digital Equipment Corporation. In 1957 he established the company in a rented corner of an old textile mill in Maynard, Mass. DEC has since grown into a $9-billion company that boasts of being the world's leader in networked computer systems.

DEC's product line encompasses personal computers, workstations, minicomputers, and clusters that serve a thousand workers. This diversity gives DEC a strong position in a variety of computer markets, from industrial control and scientific calculation to data processing and office automation.

Like his company, the 61-year-old Olsen has quite a reputation. He's an outspoken, sometimes irascible, largely enigmatic leader who's driven his company to success. HIGH TECHNOLOGY BUSINESS assistant managing editor Jeffrey Zygmont spoke with Olsen about the future of the computer industry.

HT Business: What single thing does business and industry need most from computer makers right now?

OLSEN: I am filled with prejudices and enthusiasm for the answer to that question. Not everyone sees it this way, but from my prejudiced point of view—prejudiced because it's been our strategy for 10 years—the greatest need is to

Kenneth H. Olsen
Born: Feb. 20, 1926
Founded DEC: 1957
Responsibilities:
Overall strategic, operational management
Revenue controlled:
$9.4 billion/year
Employees supervised:
114,100
1987 R&D budget:
$1 billion

WALTER BIBIKOW

tie together all parts of an organization to allow them to work together. This means that work groups, as we call them, can be expanded and contracted spontaneously, as the need develops. They can share computing software and transmit pictures, documents, and data. It's just common sense. If you can get the whole organization to work together, it's so much more effective.

A few years ago we were ridiculed because we said that personal computers working alone weren't good enough. But people thought miracles would happen when they used personal computers. Miracles didn't happen because they weren't tied together to work on a common problem. When everybody in an organization has a different personal computer, different software, different spreadsheets, different word processing, they obviously do not work together. Networking can force them to work together.

HT Business: What will the fully networked company look like?

OLSEN: It's like the telephone. Any time you want to hook up a telephone, you plug it into the wall and it's in. People are free to communicate. I think the same is true with a networked company. Take the way we used to introduce a product. I'd have a drawing. If the engineering group had a problem, it would contact manufacturing or outside suppliers. They'd make suggestions, mark up the drawing, and send it back to engineering. The engineer would finally get it, finally mark it up and send it back to manufacturing. They'd go through the whole thing a few times. Each argued a point of view, but it took forever to introduce a product.

In networked companies, the group that is introducing the product has a database and can spontaneously absorb these changes on a CAD [computer-aided design] system. People in engineering, in other departments, and at the supplier can all make the same part together, even if they are miles apart. They can bring on a change; push the button and that's it.

I have four secretaries here. They all work on one database, one computer. They have complete access to each other's files and records. Anybody can start a job and anybody else can pick it up. If somebody calls up and wants to know what happened to a letter, anyone can find out. Before the caller finishes telling his name and address, a secretary knows what was done with the letter. They work as a team.

HT Business: How well is the computer industry fulfilling this need to network computers?

OLSEN: It is surprisingly mixed. We had a vision that every part has to communicate completely, uniformly, and homogeneously with all other parts of an organization, *and* its suppliers, and the companies it supplies. This idea is so obvious.

But that feeling is not very widely shared in the industry, partly because networking takes a big investment and partly because it is very complex when you try to integrate a whole organization. Individual networks are very simple. Anybody could tie a few PCs together from what they buy in the computer store. To tie an organization together, with different departments, different vehicles of communication between departments, different vehicles of communication across the country, across the world, at different speeds, with different ways of sharing databases, sharing computers—all these things make networking one of the most complex technologies in the world today. At the same time, I say the concept is very simple, but it takes a lot of investment, and people don't have quite the vision to make the investment. So it's slow in getting going.

We started by making simple compromises 14 years ago: We have one computer architecture, one software system. The longer you postpone doing that, the harder it gets.

HT Business: When will major customers demand widespread computer integration?

OLSEN: Computer users aren't yet ready to tie together their whole organization, because it is a major social change. That means it takes time. They'll probably sneak up on it by networking pieces to accomplish specific needs.

They are networking larger and larger parts: a complete office, big laboratories, big factories. Some people say it's too difficult to get various parts of the world to work together, so they're not going to try. But the payoff could be enormous.

HT Business: Traditionally, the computer market has been segmented. How long will this continue?

OLSEN: We're bringing down the barriers. The equipment is getting to be more and more the same. A lot of the software is getting closer.

The things on the big computers, the big databases, will probably stay there. However, transaction-processing projects will get distributed to smaller databases, and distinctions between terminals, PCs, and workstations will blur.

"In the long term, the industry will end up with a very small number of manufacturers."

HT Business: As such distinctions disappear, how will the market for large commercial computers change?

OLSEN: The market still breaks down into two groups. There are people who don't want to pay very much for service. They definitely want to design the system; often they want to maintain it. And there are people who have a large number of computers, large complex systems. They want the supplier to do the design, install it and maintain it. That's the traditional mainframe, MIS [management information system] customer. The engineering customer wants to design it himself. That difference will stay.

HT Business: In your view, which approach is better?

OLSEN: Oh, they're both appropriate. A large financial organization does not want to have anything to do with the design, operation, or maintenance of a computer system. And the technical companies love to adapt the system.

HT Business: Do you foresee any significant changes in the size of the computer market?

OLSEN: I don't know about the overall market. We have a small part of it. From our point of view there will be no difficulty from the size of the market.

HT Business: Does that mean the market will grow, or that DEC will gain market share?

OLSEN: We've been getting more and more market share, so I think that will continue.

HT Business: In manufacturing, there have been some widely publicized problems with computer networks and advanced automation—General Motors' Hamtramck plant comes to mind. How do you account for such problems?

OLSEN: Advanced automation works, if it's done for the right reasons. If your goal is to conquer something, it's not unlikely that you'll succeed. But if your goal is to do something else, you might succeed at that, but it's not going to help the bottom line.

If a company's interest is in designing its own thing, and having everything made special because it's the company's idea—if that's even more important than making the thing work—they're going to have trouble for a long time. If you really question people about what they're doing, what their goals are, you can sense a problem. Their first goal is not to make it work. The first goal is to use their own ideas.

HT Business: The "not-invented-here" syndrome.

OLSEN: But it's almost worse than that. If a person says he's got to make his own automobile, he's crazy. He can buy what's available. That's smart.

HT Business: A lot of companies jumped into advanced automation—computer control—thinking that it would be the salvation of U.S. manufacturing. Were they wrong?

OLSEN: Computers only do what they're told. But you have to have something specific you want done. People said, "Buy personal computers; they're going to revolutionize all of industry." They said miracles would happen.

Miracles don't happen. You have to know why you're doing things. Putting a robot in just to put a robot in, or putting automation in just to put automation in, or computers in to put computers in—it may help, but it's unlikely. You've got to decide why you want a computer.

HT Business: In other words, companies have to keep their priorities straight?

OLSEN: Goals are better than priorities. Know what you want to do.

HT Business: Have U.S. businesses been remiss at getting their goals straight?

OLSEN: They've been terribly remiss with the personal computer. That's part of what caused the computer recession—companies went out and bought all kinds of computers and nothing happened. They bought a lot of robots and nothing happened, so the robot industry is devastated. The robots they bought for specific jobs are probably doing well. But robots they bought just because robots were supposed to be good—nothing happened.

HT Business: Have companies learned anything from these mistakes?

OLSEN: Some of them, very much so. Some of them still don't know why they want to do it.

HT Business: Do you foresee any significant restructuring of the computer industry?

OLSEN: One thing that's going to happen in the long term—and that means very soon or not so soon—is that the industry will end up with a very small number of manufacturers. In the manufacturing of hardware, that's definitely going to happen, because the world doesn't need many types of computers. I figure there were about 500 companies making personal computers. Almost all those have disappeared, though there are still a handful. That's the way the market works. And the people who make software can't make it for a lot of different computers. So I think that's one change. It's happened to every other industry.

HT Business: Do you care to predict when this shakeout may come?

OLSEN: No. Everybody who guesses is always wrong, so you can be sure I'd be wrong too.

HT Business: Which companies do you feel are in a good position to survive?

OLSEN: There are always niches that people will find. But in the mainframe business, well, one thing you might do is look and see who spends the most money on research and development. That's probably going to be a major factor in who stays and who doesn't. Computers are getting more expensive to design, and software systems are getting more expensive.

HT Business: What is DEC's strategy for assuring a place in the future computer market?

OLSEN: I think the future is pretty much obvious. I'd like to concentrate on networking now for a long time.

HT Business: How long?

OLSEN: Oh, for a long time yet. Long enough that I won't talk about it.

HT Business: That raises the question of your selecting a successor.

OLSEN: Oh, that's a foolish question. Picking a successor is a kiss of death. The only preparation you can give a potential successor is to keep him working and see if he survives.

HT Business: But outside the company, people think of DEC as Ken Olsen's company. They wonder what will become of it when you're gone.

OLSEN: People don't realize that a lot of the things I do are not the things they think I do. The important strategies come from people other than me. I'm smart enough, when they're good, to act upon them. But the strategies, the ideas, the plans, usually don't come from me. I spend full time getting other people to do the work. So at least for a while the company won't miss me.

HT Business: So you're saying DEC is not Kenneth Olsen's company?

OLSEN: Yeah. Hopefully it'll get someone smarter next time. ■

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EasyNet 116 network. A high-speed card and software for communications between IBM and compatible personal computers. $495 per station; $990 for a two-station starter kit. EasyNet Systems Inc., 4283 Village Centre Ct., Mississauga, Ontario, Canada L4Z 1S2. (800) 387-3207; in Canada, (416) 273-6410. *Circle 2.*

Excel spreadsheet. MS-DOS software that links spreadsheets; offers on-sheet database management and custom graphs. The program runs on 80286/80386-based personal computers and needs 640 kilobytes of memory, a hard disk, and a graphics adapter card. Compatible with Lotus 1-2-3. $495. Microsoft Corp., 16011 N.E. 36th Way, Redmond, WA 98073. (206) 882-8080. *Circle 3.*

Laserboard printer sharer. This plug-in board lets three personal computers share a Hewlett-Packard Series II laser printer. $495. Digital Products Inc., 108 Water St., Watertown, MA 02172. (800) 243-2333; in Mass., (617) 924-1680. *Circle 4.*

Nefax-25 fax machine. Improves facsimile networking in large business applications. Sends a page in nine seconds. $4,295. NEC America Inc., Facsimile Div., 8 Old Sod Farm Rd., Melville, NY 11747. (800) 782-7329; in N.Y., (516) 753-7406. *Circle 5.*

UX-80 fax/copier/phone. Made for home offices. The copier offers enlargement and reduction; fax transmission takes 40 seconds. $1,499. Sharp Electronics, Personal Home Electronics Div., Sharp Plaza, Mahwah, NJ 07430. (201) 529-9518. *Circle 6.*

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COMPUTER HARDWARE

Portable Office portable computer. An 80286-based computer with a 40-megabyte hard drive, a 1.2-megabyte floppy disk, parallel and serial ports, and six expansion slots. Its 640-kilobyte random-access memory expands to one megabyte. Backlit liquid-crystal screen shows 25 lines of 80 characters. Weighs 20 pounds. $3,295. IMC International Inc., 10 Northern Blvd., Amherst, NH 03031. (603) 595-2336. *Circle 8.*

CacheCard accelerator board. Doubles the Machintosh SE's speed and performance. Adds 64 kilobytes of random-access memory, a 16-megahertz processor, an onboard expansion port, and an optional math coprocessor. Less than $700. Levco, 6160 Lusk Blvd., Suite C-203, San Diego, CA 92121. (619) 457-2011. *Circle 9.*

Deskpro 386/20 computer. This 80386-based personal computer has one megabyte of random-access memory and another 32 kilobytes of static memory as a cache. Includes a 60-megabyte hard disk, a 5¼-inch disk drive, and interfaces for parallel and asynchronous communications. Three models from $7,499 to $12,499. Compaq Computer Corp., 20555 FM 149, Houston, TX 77070. (713) 370-0670. *Circle 10.*

DMP 2120 dot-matrix printer. Produces 240 characters/second with a 24-wire printhead. Emulates the Tandy character set and the IBM PC graphics printer. Color option. $1,599. Tandy Corp., 1800 One Tandy Center, Fort Worth, TX 76102. (817) 878-4969. *Circle 11.*

Dolch-Pack portable computer. A 20-lb. unit based on the 80386 processor; has two megabytes of random-access memory (eight megabytes optional). Handles two million instructions/second. Backlit liquid-crystal screen displays 25 lines of 80 characters. $5,995 for a version with 20-megabyte memory; $6,495 for 40 megabytes. Dolch Computer Systems, 2029 O'Toole Ave., San Jose, CA 95131. (408) 435-1881. *Circle 12.*

Falcon coprocessor. This add-in card and software turns an IBM PC/XT/AT or compatible computer into a minicomputer system. Executes Data General's Nova instructions and emulates 16-bit Eclipse commands. $3,975. Strobe Data Inc., 13240 Northup Way, Bellevue, WA 98005. (206) 641-4940. *Circle 13.*

LP 1000 laser printer. Produces full-page graphics at six pages/minute with a resolution of 300×300 dots/inch. $2,199. Tandy Corp., 1800 One Tandy Center, Fort Worth, TX 76102. (817) 878-4969. *Circle 14.*

MMi-100 optical-storage subsystem. Lets users access a write-once, read-many (WORM) optical-disk drive as if it were a Winchester drive. Works with the IBM PC/XT/AT and compatible computers. $6,495. Micro Mart Inc., 8620 N. 22nd Ave., Phoenix, AZ 85021. (602) 997-9699. *Circle 15.*

P7080-A laser printer. Produces eight pages/minute in six fonts. Has heavy-duty engine for durability; handles 10,000 pages/month, according to the company. Works with most computers. $3,895. Facit Inc., 9 Executive Park Dr., Merrimack, NH 03054. (603) 424-8000. *Circle 16.*

PXL-350/4 light pen. Works with the IBM Personal System/2 Model 30. Includes controller board, software, and an adapter cable. $189. FTG Data Systems, Box 615, Stanton, CA 90680. (714) 995-3900. *Circle 17.*

SP-300/600 surge protectors. Shields computers and other equipment from electrical surges. Model SP-300 upgrades a standard wall outlet to three protected outlets and handles spikes to 6,000 volts. Model SP-600 provides six outlets and 4,500-volt protection. $15.95 and $17.95. Ohm/Electronics Inc., Scooter Products, 746 Vermont St., Palatine, IL 60067. (800) 323-2727; in Ill., (312) 359-6040. *Circle 18.*

ST45-50 hard drive. This internal drive slides into the IBM Personal System/2 Model 50 to double the memory. Also speeds ac-

cess by three times. $1,395. TW Technologies Inc., 21636 N. 14th Ave., Phoenix, AZ 85027. (602) 581-0669. *Circle 19.*

StretchScreen Macintosh monitor. Holds six times the on-screen information of a standard Macintosh screen. The 20.5-inch monitor includes software to allow viewing on both the standard screen and the large screen. $2,095. Network Specialties, 1485 Bayshore Blvd., San Francisco, CA 94124. (415) 467-8411. *Circle 20.*

T5100 portable computer. Has an 80386 processor, an 80387 coprocessor socket, two megabytes of random-access memory, a 40-megabyte hard disk, and a 1.44-megabyte disk drive that's compatible with the IBM Personal System/2. Weighs 15 pounds. $6,499. Toshiba America Inc., Information Systems Division, 9740 Irvine Blvd., Irvine, CA 92718. (714) 380-3000. *Circle 21.*

■ COMPUTER SOFTWARE

Art Gallery Fantasy art library. A collection of clip-art monsters, mythical creatures, and fantasy symbols for use with PrintMaster Plus and NewsMaster desktop-publishing software. $29.95; $24.95 for the Commodore version. Unison World, 2150 Shattuck Ave., Suite 902, Berkeley, CA 94704. (415) 848-6670. *Circle 22.*

Loan Ranger amortizer. Helps calculate and keep track of payments for balloon loans, Rule of 78s, actuarial-method loans, and U.S. Rules-method loans. Handles as many as 500 modified payments to determine how extra payments affect the total finance charge. $99.95. Pride Software Development Corp., 8221 Glades Rd., Suite 202, Boca Raton, FL 33434. (800) 635-6366; in Fla., (305) 731-4333. *Circle 23.*

QUED/M editor and database. A Macintosh program that combines a macro editor, a text database manager, and an appointment calendar. Adapts to suit individual needs. $119. Paragon Concepts Inc., 4954 Sun Valley Rd., Del Mar, CA 92014. (619) 481-1477. *Circle 24.*

Secret Guard security system. This two-password program prevents unauthorized access to a computer system's hard disk. $79.95. Pride Software Development Corp., 8221 Glades Rd., Suite 202, Boca Raton, FL 33434. (800) 635-6366; in Fla., (305) 731-4333. *Circle 25.*

Sled graphics tool. Lets users incorporate scanned photos, logos, signatures, and line art into text, using nearly any word processor. Flips, rotates, mirrors, shears, enlarges, and reduces images. Works with Hewlett-Packard, Cordata, Ricoh, and Canon laser printers. $149.95. VideoSoft Inc., VS Software Division, Box 6158, Little Rock, AR 72216. (501) 376-2083. *Circle 26.*

Touch 'n Go expense reporter. Automates expense reporting for reimbursement, billing, and tax purposes. Provides notes, printed reports, and year-end summaries to support tax claims. $99. Quantic Corp., 44 Friendly Dr., Smithtown, NY 11787. (800) 628-2828; in N.Y., (516) 361-3322. *Circle 27.*

■ COMMERCIAL/INDUSTRIAL

5100 super-minicomputer. This reduced-instruction-set computer uses parallel execution to perform at 14 million Whetstones/second for floating-point operations. Has 128 kilobytes of cache memory—64 kilobytes for code and 64 kilobytes for data. The 144-megabyte main memory expands to one

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- ☐ F. Machinery
- ☐ G. Computers Software
- ☐ H. Other_____

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- ☐ 3. Vice-President
- ☐ 4. Treasurer
- ☐ 5. General Manager
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- ☐ 2. 20-99
- ☐ 3. 100-499
- ☐ 4. 500-999
- ☐ 5. 1000+

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- ☐ A. Under $500,000
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5	35	65	95	125	155	185	215	245	275	305	335	365
6	36	66	96	126	156	186	216	246	276	306	336	366
7	37	67	97	127	157	187	217	247	277	307	337	367
8	38	68	98	128	158	188	218	248	278	308	338	368
9	39	69	99	129	159	189	219	249	279	309	339	369
10	40	70	100	130	160	190	220	250	280	310	340	370
11	41	71	101	131	161	191	221	251	281	311	341	371
12	42	72	102	132	162	192	222	252	282	312	342	372
13	43	73	103	133	163	193	223	253	283	313	343	373
14	44	74	104	134	164	194	224	254	284	314	344	374
15	45	75	105	135	165	195	225	255	285	315	345	375
16	46	76	106	136	166	196	226	256	286	316	346	376
17	47	77	107	137	167	197	227	257	287	317	347	377
18	48	78	108	138	168	198	228	258	288	318	348	378
19	49	79	109	139	169	199	229	259	289	319	349	379
20	50	80	110	140	170	200	230	260	290	320	350	360
21	51	81	111	141	171	201	231	261	291	321	351	381
22	52	82	112	142	172	202	232	262	292	322	352	382
23	53	83	113	143	173	203	233	263	293	323	353	383
24	54	84	114	144	174	204	234	264	294	324	354	384
25	55	85	115	145	175	205	235	265	295	325	355	385
26	56	86	116	148	178	208	236	268	298	328	358	388
27	57	87	117	147	177	207	237	267	297	327	357	387
28	58	88	118	148	178	208	238	268	288	328	358	388
29	59	89	119	149	179	209	239	269	299	329	359	389
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gigabyte. $109,000 to $148,000. Ridge Computers, 2451 Mission College Blvd., Santa Clara, CA 95054. (408) 986-8500. *Circle 28.*

7960 electronic counters. These devices count such quantities as parts, cycles, strokes, and units of length or volume. $195 to $285. Veeder-Root Co., 70 Sargeant St., Hartford, CT 06102. (800) 243-4458; in Conn., (203) 527-7201. *Circle 29.*

Argus 750 inspection system. Measures distances and angles in two fields of view to give dimensions of parts that are too big to be viewed with one camera. Has a 68020 processor. From $25,000. American Cimflex Corp., 160 Industry Dr., Pittsburgh, PA 15275. (412) 787-3000. *Circle 30.*

Armored cable. Any of the company's Series B breakout or Series D tight-buffered fiber-optic cables are available with steel armor that permits indoor/outdoor use. From 50 cents/meter. Optical Cable Corp., 870 Harrison Ave., Salem, VA 24153. (703) 389-9900. *Circle 31.*

Armored light pens. Made to survive public use on video games or terminals. $174. Interactive Computer Products Inc., 23591 El Toro Rd., Suite 180, El Toro, CA 92630. (714) 770-5332. *Circle 32.*

BCS-250 bar-code system. A plug-in board that converts an IBM PC/XT/AT or compatible computer into a bar-code scanner. Security features prevent unauthorized use. $895. Aedex Corp., 1070 Ortega Way, Placentia, CA 92670. (714) 632-7000. *Circle 33.*

Durable bar-code labels. These labels survive harsh industrial environments and will last 30 years, according to the company. Prices vary. Computype Inc., 2285 West County C Rd., St. Paul, MN 55113. (800) 328-0852; in Minn., (612) 633-0633. *Circle 34.*

Eagle 2450/2480 scanners. Both models convert mechanical drawings into raster formats that are compatible with computer-aided-design systems. They handle 24-inch-wide drawings (40 inches optional) on Mylar, vellum, or film. Model 2450 offers resolutions of 200 to 1,000 lines/inch; Model 2480 resolves 200 to 1,600 lines/inch. $55,000 and $60,000. ANA Tech Corp., 10499 Bradford Rd., Littleton, CO 80127. (303) 973-6722. *Circle 35.*

Fatigue fuses. These devices monitor stresses to warn of impending structural failures in aircraft, ships, bridges, power plants, etc. From $200 each in lots of 100. Tensiodyne Corp., 417 Caredean Dr., Horsham, PA 19044. (215) 443-9510. *Circle 36.*

Flex-Station workstation. A graphics workstation that performs micro-to-mainframe interactive batch processing. Also stands alone as an MS-DOS and Unix station. From $4,995. Sumitronics Inc., 580 N. Pastoria Ave., Sunnyvale, CA 94086. (408) 737-7683. *Circle 37.*

Helium-Neon particle-size analyzer. Measures particles as small as 0.9 micrometers; particles may be dry or in liquid. Price varies. Sitco, 7E Easy St., Bound Brook, NJ 08805. (201) 271-5900. *Circle 38.*

HP 3787B digital tester. Checks digital transmission on T1 and digital-data service (DDS) networks; also tests 56-kilobit/second switched and packet-switched services. $8,000. Hewlett-Packard Co., 1820 Embarcadero Rd., Palo Alto, CA 94304. Call local Hewlett-Packard sales office. *Circle 39.*

HP 4954A protocol analyzer. Monitors, analyzes, and simulates data traffic on wide-area and local-area networks. $17,000. Hewlett-Packard Co., 1820 Embarcadero Rd., Palo Alto, CA 94304. Call local sales office. *Circle 40.*

HVMP microfiche printer. Produces single-sided microfiche documents as fast as 120 pages/minute; prints double-sided at 60 pages/minute. Keeps usage records for 200 accounts. $415,000. Xerox, Special Information Systems, 3100 Foothill Blvd., Pasadena, CA 91107. (818) 351-2351. *Circle 41.*

STATEMENT OF OWNERSHIP, MANAGEMENT, AND CIRCULATION (Required by 39 U.S.C. 3685). 1A. High Technology Business. 1B. Publication No. 08958432. 2. October 30, 1987. 3. Monthly. 3A. Twelve. 3B. $30.00. 4. High Technology Business, 214 Lewis Wharf, Boston, MA 02110. 5. High Technology Business, 214 Lewis Wharf, Boston, MA 02210. 6. The names and addresses of the publisher, editor, and managing editor are: Publisher, Charles L. Martin Jr., High Technology Business, 214 Lewis Wharf, Boston, MA 02210; Editor, same as above; Managing Editor, Mary H. Frakes, High Technology Business, 214 Lewis Wharf, Boston, MA 02110. 7. Owner is Infotechnology Inc., 600 Madison Ave., Suite 2100, New York, NY 10022. 8. The known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of the total amount of bonds, mortgages, or other securities are: None. 9. N/A. 10A. Total number of copies printed: average number of copies of each issue during preceding 12 months—295,500; single issue nearest to filing date—252,500. 10B. Paid circulation: 1. Sales through dealers, average number of copies of each issue during preceding 12 months—16,967; single issue nearest to filing date—16,000; 2. Mail subscription, average number of copies of each issue during preceding 12 months—204,353; single issue nearest to filing date—174,174. 10C. Total paid circulation: average number of copies of each issue during preceding 12 months—221,320; single issue nearest to filing date—190,174. 10D. Free distribution by mail: average number of copies of each issue during preceding 12 months—5,079; single issue nearest to filing date—4,464. 10E. Total distribution: average number of copies of each issue during preceding 12 months—226,399; single issue nearest to filing date—194,638. 10F. Copies not distributed: 1. Office use, average number of copies of each issue during preceding 12 months—6,460; single issue nearest to filing date—9,176; 2. Return from news agents, average number of copies of each issue during preceding 12 months—62,641; single issue nearest to filing date—48,686. 10G. Total: average number of copies of each issue during preceding 12 months—295,500; single issue nearest to filing date—252,500. I certify that the statements made by me above are correct and complete. Diane Gross, Business Manager.

Mark 6 super-minicomputer. Supports more than 64 users with direct memory access; executes programs written in Iris Business Basic, Basic Four Business Basic, Throughbred Basic, and Blis/Cobol. Stores 1.35 gigabytes on a Winchester disk and 500 megabytes as backup on cartridge tape. From $35,000. Point 4 Data Corp., 15442 Del Amo Ave., Tustin, CA 92680. (714) 259-0777. *Circle 42.*

MBL-300 laser scanner. When attached to a bar-code decoder, this hand-held device performs noncontact scanning at a rate of 36 scans/second. $795. Aedex Corp., 1070 Ortega Way, Placentia, CA 92670. (714) 632-7000. *Circle 43.*

MDI 6100 portable terminal. By sending and receiving radio waves, this briefcase-sized terminal permits real-time, two-way data communication with a central computer without a wired link. Price varies. Mobile Data International Inc., 11411 Number Five Rd., Richmond, British Columbia, Canada V7A 4Z3. (800) 663-7634; in Canada, (604) 277-1511. *Circle 44.*

MSR-100/MBR-150 credit-card reader. Reads the data encoded on credit cards and converts it to ASCII format for display on a cash register or terminal. Model MBR-150 has an optional bar-code feature. $395 and $695. Aedex Corp., 1070 Ortega Way, Placentia, CA 92670. (714) 632-7000. *Circle 45.*

Symbol Screen bar-code shield. This pressure-sensitive film conceals a bar-code image but lets infrared wands and scanners read the code. The film bonds to the bar-code label and destructs if anyone tries to remove it. Bar Code Media Solutions, 4866 Cooper Rd., Cincinnati, OH 45242. (513) 791-4880. *Circle 46.*

Tartan XP80 page reader. Using optical character recognition, this device scans forms for fast data entry. It recognizes both machine-printed and hand-printed characters, even if they're on the same line. From $285,000. Recognition Equipment Inc., 2701 E. Grauwyler Rd., Irving, TX 75061. (214) 579-6000. *Circle 47.*

TDR cable-fault locator. Hand-held; finds faults in telephone and power cables as long as 9,500 feet. Four ranges; accurate to 3 percent of selected range. $1,060. Biddle Instruments, 510 Township Line Rd., Blue Bell, PA 19422. (215) 646-9200. *Circle 48.*

■ MANUFACTURING SUPPLIES

APT4530AN/5030AN MOSFETs. These devices swing 12,000 volts/microsecond for power supplies, motor controllers, voltage regulators, and converters. Model 4530 offers 450-volt operation; the 5030, 500 volts. $18.23 and $14.58 each in lots of 1,000. Advanced Power Technology, 405 S.W. Columbia St., Bend, OR 97702. (800) 222-8278; in Ore., (503) 382-8028. *Circle 49.*

R9696DP OEM modem board. A V.32 synchronous/asynchronous board that operates over public switched telephone networks or leased lines at 9,600 bits/second. $450 each in lots of 1,000. Rockwell International Corp., Semiconductor Products Div., Box C, M.S. 501-300, Newport Beach, CA 92658. (800) 854-8099; in Calif., (800) 422-4230. *Circle 50.*

■ CONSUMER PRODUCTS

Computersmarts educational toy. Teaches language, math, and computer skills to children age six and older. Works with a VCR or stands alone. $99 to $129; $19 to $24 for additional cassettes. Connor Toy Corp., 200 Fifth Ave., Suite 903, New York, NY 10010. (212) 242-4300. *Circle 51.*

CT-300 cordless telephone. Offers memory dialing, automatic redial, and a liquid-crystal display. $1,499. Tandy Corp., 1700 One Tandy Center, Fort Worth, TX 76102. (817) 878-4852. *Circle 52.*

Heathkit H-386 computer kit. Builds a 16-megahertz desktop computer based on a 32-bit 80386 processor. Includes a socket for an 80287 or 80387 numeric coprocessor. $3,349.95. Heath Co., Dept. 350-010, Hilltop Rd., St. Joseph, MI 49085. (616) 982-3200. *Circle 53.*

Jetset in-flight headphones. These stereo headphones offer better sound than the headsets on commercial airlines. $19.95. Executive Travelware, Box 59387, Chicago, IL 60659. (312) 944-7610. *Circle 54.*

Monopoly software. A computer version of Parker Brothers' real-estate game. $29.99. Virgin Games Ltd., c/o Bobbi Marcus Public Relations Inc., 1616 Butler Ave., West Los Angeles, CA 90025. (213) 479-2001. *Circle 55.*

Quad Mesh 10 satellite antennas. Four-piece antennas made with expanded, rolled aluminum mesh. They attach to a cradle for strength and easy installation. $379 to $419. Channel Master, Box 1416, Smithfield, NC 27577. (919) 934-9711. *Circle 56.*

Scrabble software. This computer version of Selchow & Righter's word game offers four skill levels and includes a software dictionary. $29.99. Virgin Games Ltd., c/o Bobbi Marcus Public Relations Inc., 1616 Butler Ave., West Los Angeles, CA 90025. (213) 479-2001. *Circle 57.*

MARKETWATCH

NEW COMPANIES

COMPANY	BUSINESS OBJECTIVE	FINANCING	OFFICERS	OFFICERS' PREVIOUS POSTS
Altera 3525 Monroe St. Santa Clara, CA 95051 (4DB) 9B4-2B00	To design, develop, and market user-configurable integrated circuits and associated computer-aided engineering systems.	Not available; public offering postponed	Rodney Smith, president, CEO	Linear Division of Fairchild, v.p., general manager
Archetype 145 South St. Boston, MA 02111 (617) 482-2739	To produce and market electronic publishing software.	Undisclosed amount from first-round financing	Michael Gold, president Paul Trevethic, chairman, CEO	Atex, v.p. marketing Lightspeed Computers, co-founder
Conductus 2275 E. Bayshore Rd. Palo Alto, CA 943D3 (415) 494-7B36	To develop and commercialize superconductors for very-high-speed digital devices, magnetic-field sensors, and interconnection between integrated circuits and printed-circuit boards.	$6 million from first-round financing	John Shoch, president, CEO Tony Sun, CFO	Asset Management, general partner (current) Venrock Associates, general partner (current)
Danninger Medical Technology 880 Kinnear Rd. Columbus, OH 43212 (614) 488-7961	To design, manufacture, and market continuous-passive-motion machines and other electro-mechanical medical devices.	$1 million from initial public offering (symbol: DANN)	Edward R. Funk, president George Skulski, v.p. marketing	Funk Metallurgical, founder Funk Metallurgical, marketing manager
Data Capture Institute 30 Tremont St. Duxbury, MA 02331 (617) 934-7S8S	To provide research and services to users of automatic data-collection technology; also offers consulting services to the bar-code industry.	Undisclosed amount from founder	David Jarrett Collins, president, founder	Computer Identics, founder
Flextronics 3S32S Fircrest St. Newark, CA 94560 (415) 794-3539	To manufacture equipment for the computer and telecommunications industries.	$20 million from initial public offering (symbol: FLEX)	Robert Pape, senior v.p., CFO	Xitel, senior v.p.
Noven Pharmaceuticals 13300 S.W. 128 St. Miami, FL 33186 (30S) 2S3-S099	To develop, produce, and market pharmaceuticals; initially concentrating on through-the-skin drug-delivery systems.	$22D,00D from first-round financing	Steven Sablotsky, president Noreen Sablotsky, secretary/treasurer Mitchell Goldberg, v.p. corp. dev.	Key Pharmaceuticals, associate director Ciba-Geigy, marketing/sales G.K. Scott, v.p.
QuaTeq International 777 108th Ave., NE Bellevue, WA 98004 (2D6) 646-307D	To supply subsurface irrigation service systems using the AquaPearl porous pipe.	$3.4 million from parent company, Samarkand Resources Inc.	Jerry Carnwell, president Ann Miller, vice president	Cornmill Enterprises, partner Cornmill Enterprises, partner
Structural Dynamics Research 200 Eastman Dr. Milford, OH 4S1S0 (513) 576-24D0	To supply computer-aided engineering software and services to automotive, aerospace, defense, and industrial manufacturers for designing sophisticated mechanical products.	$43 million from initial public offering (symbol: SDRC)	Ronald J. Friedsam, president, CEO William Sarther, sr. v.p., CFO	Automatic Data Processing, division controller Burroughs, v.p.
TeamOne Systems 491 Macara Ave. Sunnyvale, CA 94086 (408) 749-0404	To provide computer-aided software engineering products.	Undisclosed amount from founders	David M. Hoffman, founder Mitchell Lowe, director prod. dev. David Henke, mgr. software dev.	CAE Systems, v.p. engineering Systems Libraries, director CAE Systems, founder
Teebell Box 297 Ossipee, NH 03864 (6D3) 539-4153	To develop and market PC-DOS and MS-DOS software for small businesses.	Undisclosed amount from president and French govt.	Patrice D'Humieres, president	Independent computer consultant

CONTRACTS AWARDED

AWARDED TO	AWARDED BY	AMOUNT	PURPOSE
Acumenics Research & Techn. 9990 Lee Highway Fairfax, VA 22030 (703) 359-6300	U.S. Department of Justice	$40 million (est.)	To provide automated litigation support for attorneys and staff of the department's Land and Natural Resource Division for as long as five years.
Air Products and Chemicals Box 538 Allentown, PA 18105 (215) 481-4986	NASA	$61 million	To supply liquid hydrogen for the space shuttle program.
Boeing Military Airplane Wichita, KS 67277 (316) 526-3153	U.S. Air Force, Oklahoma City Air Logistics Center	$13.5 million	To install upgraded engines on 36 KC-135 tanker aircraft.
Carltech Associates 5457 Twin Knolls Rd. Columbia, MD 21045 (202) 982-1855	U.S. Environmental Protection Agency	$2.6 million	To provide engineering, scientific, and technical-publication-development services for the EPA's Office of Research and Development.
Camptek Research 110 Broadway Buffalo, NY 14203 (716) 842-2700	U.S. Air Force	$2.2 million	To develop and implement better communication systems between defense agencies and the Army, Navy, and Air Force, as part of the Air Force's Interoperability and Tactical Support program.
Camptek Research 110 Broadway Buffalo, NY 14203 (716) 842-2700	U.S. Navy	$5.6 million	To supply equipment for computerized control of ship-based antimissile defense systems.
Camptek Research 110 Broadway Buffalo, NY 14203 (716) 842-2700	U.S. Naval Sea System Command	$7.1 million	To continue to provide technical support in reliability, maintainability, and quality control to help develop computer-based tactical systems for warships.
Camptek Research 110 Broadway Buffalo, NY 14203 (716) 842-2700	Intermetrics	$2.3-million subcontract	To test the compatibility of defense-related information systems shared by branches of the U.S. military.
Camptek Research 110 Broadway Buffalo, NY 14203 (716) 842-2700	Naval Combat Systems Engineering Station	$907,900	To provide programming and engineering support for radar automatic detection and tracking systems.
Contel Federal Systems 12015 Lee Jackson Hwy. Fairfax, VA 22033 (703) 359-7500	U.S. Air Force, Electronic Systems Division	$900,000	To study system architecture and engineering to develop a command and control information-processing system for the Military Airlift Command.
Covalent Technology 3941 Research Park Dr. Ann Arbor, MI 48106 (313) 769-1100	U.S. Agency for International Development, and the Program for Appropriate Technology in Health	$60,000	To develop a dipstick test for the hepatitis-B virus and diarrhoeal disease toxins.
Datalex 100 Pine, 24th Floor San Francisco, CA 94111 (415) 362-4466	Visa U.S.A.	$55,000	To integrate Datalex's Entrypoint 90 data-capture software into a new software package for banks belonging to the Calwestern Automated Clearing House Association.
Ericssan 100 Park Ave., Suite 2705 New York, NY 10017 (212) 685-4030	Nynex Enterprises	Not disclosed	To supply the AXE digital-switching system to Nynex subsidiary New York Telephone for interactive-message and group-bridging services.

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AWARDED TO	AWARDED BY	AMOUNT	PURPOSE
Ericsson 730 International Pkwy. Richardson, TX 75081 (214) 669-9900	Nynex Enterprises	Not disclosed	To provide an advanced digital switching system for New York Telephone's interactive-message and group-bridging services, to be introduced in 1988.
Ericssan 730 International Pkwy. Richardson, TX 75081 (214) 669-9900	BellSouth	Not disclosed	To enhance BellSouth's signal-transfer-point switch to include Class S subscriber-service features.
Genrad 300 Baker Ave. Concord, MA 01742 (617) 369-4400	Jaguar Cars	$9 million	To further develop the Jaguar Diagnostic System and associated software (an addition to a $13-million initial contract).
GTE Government Systems 100 First Ave. Walthom, MA 02254 (617) 366-6000	U.S. Air Force, Electronic Systems Division	$900,000	To study system orchitecture and engineering to develop a command and control information-processing system for the military Airlift Command.
ICF Technology 9300 Lee Highway Fairfax, VA 22031 (703) 934-3000	U.S. Environmental Protection Agency	$35 million	To manage and support analytical laboratory work for the Superfund program, which addresses hazardous-waste disposal.
Inference 5300 W. Century Blvd. Los Angeles, CA 90045 (213) 417-7997	U.S. Air Force	Not disclosed	To develop expert systems and train Pentagon personnel to implement and manage them.
Integrated Genetics 31 New York Ave. Framingham, MA 01701 (617) 872-8400	National Cancer Institute	$1.8 million	To study the effectiveness of DNA probes in assessing the inherited risk of developing certain cancers.
Integrated Genetics 31 New York Ave. Framingham, MA 01701 (617) 872-8400	Ortho Pharmaceutical	Not disclosed	To develop megakaryocyte stimulating factor, a blood protein that helps regulate platelet production; will help patients receiving chemotherapy and bone-marrow transplants.
Lauden Associates 5457 Twin Knolls Rd. Columbia, MD 21045 (301) 596-0037	Autometric	$70,000	To provide management consulting services concerning Department of Defense technology markets.
Ovonic Imaging Systems 1896 Barrett St. Troy, MI 48084 (313) 362-2738	U.S. Air Force, Human Resources Laboratory	Not disclosed	To develop a flat-panel liquid-crystal display for the Air Force's Integrated Maintenance Information System.
Quantex 2 Research Court Rockville, MD 20850 (301) 258-2701	U.S. Air Force, Rome Air Development Center	$500,000	To further develop an electron-trapping, erasable optical memory called ETOM.
Quantex 2 Research Court Rockville, MD 20850 (301) 258-2701	U.S. Nuclear Regulatory Commission	$200,000	To develop an integrating fiber-optic dosimeter using electron-trapping photonic materials.
Racal-Milgo 1601 N. Harrison Pkwy. Sunrise, FL 33323 (305) 476-5609	U.S. Defense Communications Agency	$6.5 million	To install data-communications equipment, including Omnimode system modems.
Silican Graphics 2011 Stierlin Rd. Mountain View, CA 94043 (415) 960-1980	McDonnell Douglas	$2 million	To supply Unix-based Iris 3110 3-D workstations for the design and analysis of military aircraft.

AWARDED TO	AWARDED BY	AMOUNT	PURPOSE
Singer/Link Flight Simulation Corporate Dr., M.S. 244 Binghamton, NY 13902 (607) 772-3127	U.S. Air Force	$15.4 million	To convert six F-4E weapon-systems trainers into RF-4C flight simulators (the RF-4C is the reconnaissance version of the F-4 Phantom airplane).
Singer/SimuFlite Training Intl. Box 619119 Dallas/F.W. Airport, TX 75261 (214) 456-8000	U.S. Coast Guard	$1.9 million	To maintain and support flight simulators at the Coast Guard's Aviation Training Center in Mobile, Alabama.
Systems Management American 254 Monticello Ave. Norfolk, VA 23510 (804) 627-9331	U.S. Environmental Protection Agency	$38.1 million	To supply, install, and support desktop-publishing systems and local-area networks.
Teknowledge Federal Systems 501 Marin St. Thousand Oaks, CA 91360 (805) 495-8265	Lockheed-Georgia and the Defense Advanced Research Projects Agency	$1.2 million	To define hardware and software requirements for real-time performance in the Lockheed Pilot's Associate intelligent-avionics system.
Unisys/Defense Systems 8201 Greensboro Dr. McLean, VA 22102 (703) 847-3375	U.S. Defense Department	$280 million	To supply as many as 5,000 super microcomputers, including software, memories, printers, and networking devices.
Unisys 8201 Greensboro Dr. McLean, VA 22102 (703) 847-3375	U.S. Defense Department	$196 million potential	To supply as many as 415 super analog microcomputers with associated software, memory devices, printers, network devices, and other peripherals.

JOINT VENTURES

COMPANY	COMPANY	PURPOSE	CONTACT
Cummins Engine	Hitachi Powdered Metals and Hitachi Metals International	To build a $10-million powdered-metals plant in Greensburg, Indiana.	Sintering Technologies Greensburg, IN 47240 (812) 663-5158
GE Fanuc Automation	GE Canada	To form GE Fanuc Automation Canada Inc. (to begin operating January 1, 1988) to serve the growing Canadian market for factory-automation equipment and services.	GE Fanuc Auto. Canada 940 Lansdowne Ave. Toronto, Ontario M6H 3Z4 (416) 530-5700
General Electric	Thomson-CSF (France) and VDO Luftfahrtgerate Werk Adolf Schindling (Germany)	To produce color flat-panel liquid-crystal displays at a factory in France.	General Electric 50 Fordham Rd., M.S. 45 Wilmington, MA 01887 (617) 937-4493
Symbolics, Graphics Division	Lyon Lamb	To market the Symbolics 3600 animation workstation with a video input/output subsystem for production and industrial uses.	Symbolics, Graphics Div. 1401 Westwood Blvd. Los Angeles, CA 90024 (213) 478-0681
Tandem Computers	SEL Canada and Union Pacific Railroad	To develop and market electronic monitoring and control systems, especially advanced electronic control for railroads.	AMCI 1045 N. 115th St. Omaha, NE 68154 (402) 498-4904
Western Digital	Tandon	To form a Singapore-based company called Westan Pte. Ltd., to manufacture and market 3½-inch, intelligent Winchester disk drives for personal computers.	Western Digital 2445 McCabe Way Irvine, CA 92714 (714) 863-7763
Whirlpool	Sundaram-Clayton (Madras, India)	To form TVS Whirlpool Ltd., which will manufacture household appliances.	Whirlpool, International Div. Administrative Center Benton, MI 49022 (616) 926-5000

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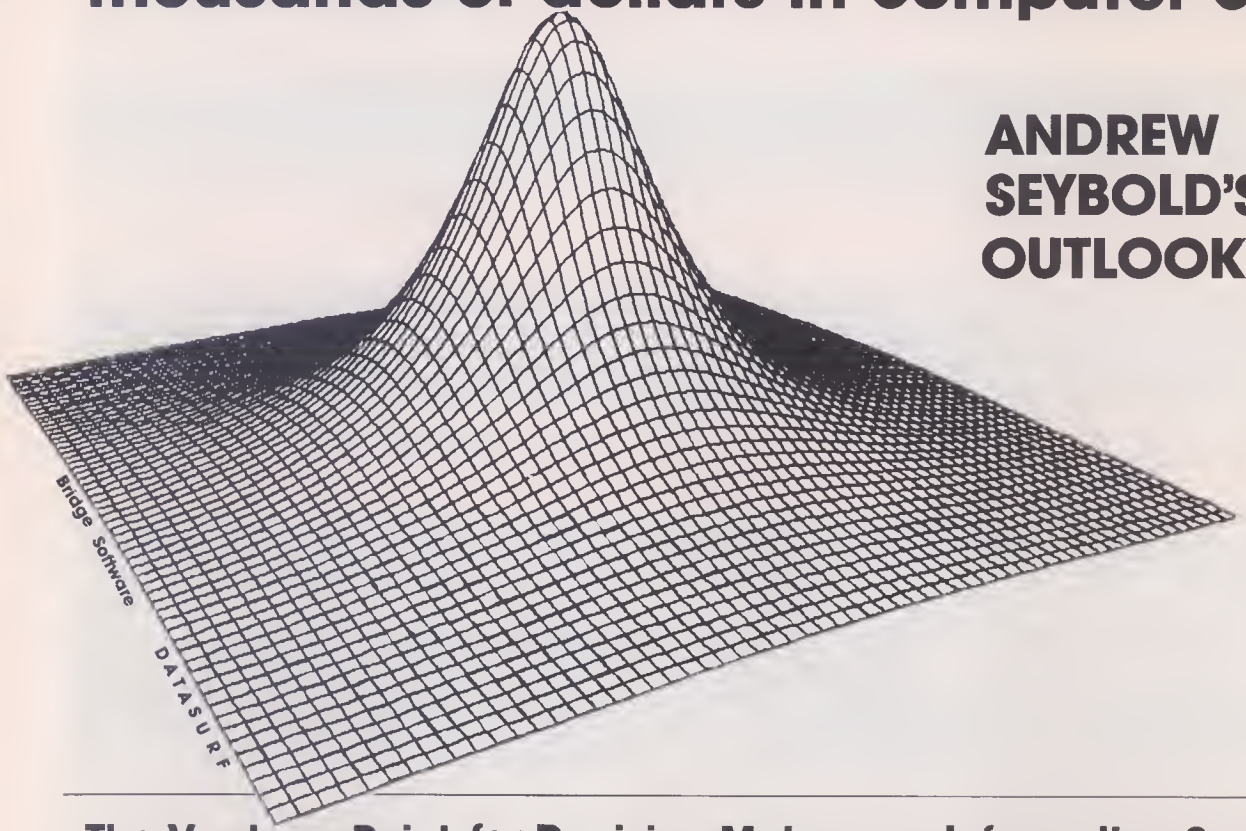

ANDREW SEYBOLD'S OUTLOOK

The Vantage Point for Decision Makers on Information Systems

Andrew Seybold's Outlook On Professional Computing

Vol. 6, No. 2 — ISSN 0894-1823 — October 26, 1987

AT&T makes a major statement of direction. At a recent meeting for analysts, the company outlined its grand vision for computing/communicating systems in the 1990s. The heyday of host-based networking is over, says Ma. Welcome the day of open standards and distributed communications tools. Page 1.

The Outlook, by Andrew M. Seybold. Reflections on the newly ignited spreadsheet wars. Page 2.

Trends in the LAN marketplace. A distillation of results from a recent quarterly survey of PC LAN decision makers. Page 5

The world of desktop publishing, according to Xerox. An interview with Allan S. Ayers, marketing manager for desktop publishing products at Xerox. Page 8.

A pair of fieldless tact minders. Free-form database programs are often ideal tools for ad hoc record-keeping. We review two newcomers, one for the Macintosh, one for the PC. Page 10.

A new critter from Microsoft. A look at the evolution of the mouse, with first impressions of the newest Microsoft Mouse. Page 12

The Fully Powered PC, by Burt Alpersen. How to get a date—the right date. Page 14.

Another month, another laptop. Specs and commentary on new lightweights from Sharp, Epson, and Toshiba. Page 17.

The Dynabook approximated. Linus Technologies is set to introduce an exciting new concept in portable computing. Page 19.

The A> Prompt, by Andrew M. Seybold. Page 21.

The future is now with the introduction of the Linus Technologies Wristop computer. See page 19.

AT&T's Bold Plan to Grab the Future

YOU'VE PAD THE headline right. Drifting around in the post divestiture fog is over for AT&T. So too is trying to be a late blooming Digital Equipment Corporation.

AT&T is alive and, more to the point, is off and running with a bold new plan to grab the future. AT&T has examined itself and has put its own business future together. On October 5-7, at the first annual AT&T Industry Analyst Conference in Holmdel, New Jersey, the company held up this strategy for the world to see. Top officers who came by and outlined the strategy included Vittorio Cassoni, AT&T's number one computer man. It was face-to-face with no questions barred, and the answers were as honest as any I've ever heard. Here's a quick summary of what was said on both sides.

(Continued on page 3)

A single mistake on professional applications of computers can cost your company thousands, even tens or hundreds of thousands of dollars in equipment costs, training, and retraining, as well as in reduced worker productivity.

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MERGERS

COMPANY	BUSINESS	COMPANY	BUSINESS	NEW NAME
BIS Banking Systems 900 Third Ave. New York, NY 10022 (212) 688-73D0	International banking systems	Computer Catalysts 21 Penn Plaza New York, NY 10001 (212) 947-8610	Trade finance software	Both companies are now subsidiaries of Nynex Information Solutions Group
Symantec 10201 Torre Ave. Cupertino, CA 95014 (408) 253-9600	Software	Think Technologies 135 South Rd. Bedford, MA 01730 (617) 275-4800	Software	Think becomes a wholly owned subsidiary of Symantec but retains its name

ACQUISITIONS

BUYER	BUSINESS	COMPANY ACQUIRED	BUSINESS	AMOUNT
Aim Telephones 299 Webro Rd. Parsippany, NY 07054 (201) 515-9400	Telephone interconnect systems	Crescent Industries 123 Langale Rd. Greensboro, NC 27409 (919) 294-6325	Interconnect-system installation and maintenance	Not disclosed
Alcon Laboratories Box 6600 Fort Worth, TX 76115 (817) 293-0450	Opthalmic drugs and surgical devices	Ivy Technologies 4221 Forrest Park Blvd. St. Louis, MO 63108 (314) 652-5150	Computer-based systems for managing medical practices	Not disclosed
Cold Heading 46D0 Bellevue Detroit, MI 48207 (313) 923-7800	Formed-steel products for the automotive industry	Micro-Term 512 Rudder Rd. St. Louis, MO 63026 (314) 343-6515	DEC-compatible graphic and alphanumeric displays	Not disclosed
Emhart Box 2730 Hartford, CT 06101 (203) 678-3000	Manufactures industriol and consumer products, information and electronic systems	Advanced Technology 12005 Sunrise Valley Dr. Reston, VA 22091 (703) 620-8000	Computer, engineering, and management services	$140 million
GM Hughes Electronics 3044 W. Grand Blvd. Detroit, MI 48202 (313) 556-5000	Advanced electronics	M/A COM Telecommunications 7 New England Executive Park Burlington, MA 01803 (617) 272-9600	Telecommunications	$105 million
Index Technology 1 Main St. Cambridge, MA 02142 (617) 494-8200	Computer-aided software engineering	Deltacom 1200 Bustleton Park Feasterville, PA 19D47 (215) 355-4758	Strategic-planning software	Not disclosed
Rolls-Royce Box 2525 Greenwich, CT 06836 (2D3) 625-8513	Automotive and aeronautic manufacturing	Matevol Limited 245/246 Europa Blvd. W. Brook, Warrington, Cheshire, England. In U.S., (404) 996-2400	Nondestructive testing equipment	Not disclosed
Spectrum Cellular 2710 Stemmans Freeway Dallas, TX 75207 (214) 630-9825	Data-transmission products	USSI 2710 Stemmons Freeway Dallas, TX 75207 (214) 630-9825	Distributes computer hardware, software, and cable products	Not disclosed
Tandem Computers 19191 Vallco Parkway Cupertino, CA 95014 (408) 725-600D	Computers	Atalla 2304 Zanker Rd. San Jose, CA 95131 (408) 435-8850	Secure transaction systems	Not disclosed
Texas Instruments Box 655474 Dallas, TX 75222 (214) 995-2011	Computers and electronics	Rexnord Automotion Box 242 Hunt Valley, MD 21030 (301) 785-6400	Industrial-control systems	$65 million

RESEARCH REPORTS

STUDY BY	TITLE	FORECAST	PRICE
Business Communications 25 Von Zant St. Norwalk, CT 06855 (203) 853-4266	Tape Automated Bonding: Applications, Materials, Suppliers and Services (#G8-104)	By 1992, tape-automated-bonding technology will be used to make 20% of all integrated circuits, an annual increase of 35%.	$1,950
Frost & Sullivan 106 Fulton St. New York, NY 10038 (212) 233-1080	Antisubmarine Warfare Platform, C^3I, and Basic Research Markets in the United States (#A1841)	The United States will spend $40 billion on antisubmarine/antimine warfare by 1990.	$1,975
Frost & Sullivan 106 Fulton St. New York, NY 10038 (212) 233-1080	AT&T Market Strategy to 1991 (#A1823)	AT&T's capital spending will reach $4.8 billion by 1991, up from 1987's $3.9 billion.	$1,900
Frost & Sullivan 106 Fulton St. New York, NY 10038 (212) 233-1080	Flat-Panel-Display Market in Europe (#E961)	By 1992, the European market for flat-panel screens will reach $1.3 billion, a 22% annual increase from the present $399-million market.	$2,650
Gartner Group Box 10212 Stamford, CT 06904 (203) 964-0096	Comtec Report on Personal Computers	As the personal-computer market matures, more than 250,000 units will be sold or scrapped this year, primarily for replacement.	$35,000
Input 1280 Villa St. Mountain View, CA 94041 (415) 961-3300	Electronic-Data-Interchange Software Markets, 1987-1992	The market will grow 55% annually to reach $88.2 million within five years.	$1,250
Input 1280 Villa St. Mountain View, CA 94041 (415) 961-3300	Federal-Processing-Services Market, 1987-1992	The market will increase from $900 million to $1.3 billion in 1992, a 7% average annual growth rate.	$1,395
Input 1280 Villa St. Mountain View, CA 94041 (415) 961-3300	User Service Requirements: Software	Software users report that documentation is usually unclear, poorly indexed, and incomplete; only 43% are satisfied with the documentation they receive.	$2,500
Market Intelligence Research 2525 Charleston St. Mountain View, CA 94043 (415) 961-9000	The U.S. Telecommunications Industry: Entrepreneurial Challenges	Although the competitive edge still rests mainly with established industry players, many market sectors present opportunities.	$995
Market Intelligence Research 2525 Charleston St. Mountain View, CA 94043 (415) 961-9000	Teleconferencing Systems: Expanding Equipment, Service, and Software Markets	The market will reach $1.8 billion by 1993, growing 20% each year.	$995
Market Intelligence Research 2525 Charleston St. Mountain View, CA 94043 (415) 961-9000	Electromagnetic-Interference-Shielding Equipment and Facilities Markets (#A163)	The market will exceed $8 billion by 1993.	$995
Market Intelligence Research 2525 Charleston St. Mountain View, CA 94043 (415) 961-9000	Humidity, Moisture, and Atmospheric Sensor Markets (#A215)	By 1993, the market will reach $347 million, with U.S. sales accounting for $174 million.	$995
Yencharis Consulting Group 11 Crooked Mile Rd. Westport, CT 06880 (203) 226-0670	Electronic Imaging Markets 1986-1988: Outlook, Obstacles & Potential	By 1988, the $4-billion electronic-imaging industry will reach $6.8 billion.	$2,500

COMPANY INDEX

The following is a list of companies mentioned in this issue and the pages on which they appear. Companies mentioned in Marketwatch and the High Technology Business Leading 100 are not included.

Better Vision, Sports Scores

OFFICE

Three-in-One Office Helper

TO EQUIP the home office, Sharp combines a facsimile machine, telephone, and photocopier into one compact unit. Dubbed the UX-80, the device is scarcely larger than a shoe box, measuring 13×6×6 inches.

The machine offers some of the features of its full-size siblings—the copier can reduce and enlarge, for instance. However, other features are scaled back to a level of performance that would be annoying in everyday use, but which are acceptable when used only occasionally in a home office. For example, the copier needs 30 seconds to make a duplicate, and it can't use paper larger than standard 8½×11-inch sheets.

Sharp expects its $1,499 fax/phone/copier to have competition, perhaps by early this year.

The UX-80 is sold by office equipment suppliers, mass merchandisers, consumer-electronics outlets, and photo stores. Sharp Electronics is based at Sharp Plaza, Mahwah, NJ 07430. Telephone (201) 529-9518.

One machine (almost) does it all.

HOME

Beepers Give The Score

FOR THOSE days so hectic that you don't have time to glance at the sports pages, an electronic service called Sports Page is available from Beeper Plus.

Sports Page relies on a Motorola beeper equipped with a special microchip for decoding digital sports-data signals that Beeper Plus transmits over a national satellite network. With a few touches on the beeper's keypad, sports fans get instant reports from three ticker services, covering professional and college football, basketball, baseball, hockey, and even horse racing. Information, including Las Vegas odds, is updated every five minutes and stored in a 2,000-character memory—enough to hold 80 games, results from three race tracks, plus personal messages from a standard paging service. Information appears on the beeper's one-line, liquid-crystal screen.

Pager keeps sports fans in the game.

The average price of the battery-powered pager is $325, depending on region, with an additional $45 per month for the sports service ($55 if a regular paging service is included). So far, Sports Page is available in about 15 major metropolitan areas, and may grow as demand increases.

Beeper Plus is located at 3900 Paradise Rd., Suite 110, Las Vegas, NV 89109. Telephone (702) 737-5560.

HEALTH

Contact Lens Splits Images

HOLOGRAPHIC technology—a method of concentrating light—is being harnessed to create bifocal contact lenses for people who need one lens for ordinary vision and another for close-up work.

The hard contact lens, called the Diffrax, is etched with concentric rings that split incoming light and make two images that have equal intensity but different focal points. The wearer's brain automatically selects the proper image on which to focus, depending on where the person is looking.

Other bifocal lenses are available, but they work by dividing their surface into two separate lenses. According to Pilkington, the British glassmaking company that developed the Diffrax lens, the separate lenses create blurry vision under certain conditions. The Diffrax uses its entire surface to focus both images.

People adapt to the lenses in less than a week, says Pilkington. The holographic surface, etched two microns into the inside of the lens by a diamond-tipped lathe, is still smooth enough to preclude injury to the cornea.

The Diffrax has been available in the United Kingdom since September, selling for the equivalent of $410. Sola Ophthalmics, a contact-lens maker in Phoenix, Ariz., is testing the lens in the United States. Michael Ness, Sola's director of marketing, expects the lens to go on sale sometime between mid-1988 and mid-1989. International Hydron of Woodbury, N.Y., is also developing its own version of the lens. ■

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- **Guest Interviews** Your company's ideas discussed and broadcast for 4 minutes on "Financial Inquiry," our program on the Learning Channel, $150 per run, using any 800 number for direct response. On FNN ("Take 5") we can place that interview for $500 to $2400 per run, plus talent fee, and production expenses.
- **Commercial Spots** Your company's 30, 60, and 120 second color spot can be strategically placed on cable television, and radio, for $150 to $2000 per run; costs vary by the network, length, time, day, and frequency, using any 800 number. TV commercials produced in our L.A. studios for approximately $2500, includes talent.
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  - **Semi Solo**—multiple use leads $20 ea. and up.
  - **Multiple**—general use leads $15 ea. and up.

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